The challenges of ToMT and Performance in the OSRE and beyond: the role of '*a system of forces*' and EoT

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Abstract

Transfer of modern technology (ToMT) including upgrading/alterations/additions (As & As)) through individuals' organizational effectiveness of training (EoT) in the Omani ships' repairs environment (OSRE) remains a challenging issue, particularly with regards to the future of on-going projects such as ships/maritime materiel, infrastructure and platforms that continue their operations for many years after acceptance dates. ToMT/upgrading is done to enhance the capability of the whole dockyard/navy through a predetermined arrangement, involving many areas of interest such as the knowledge, competencies and skills (KCS) of the indigenous workforce to support the capability. Typical examples that can drag/slow down the modern KCS development of the indigenous workforce are to fully depend on the outside contracts, manpower substitution, external organization and institutions to do the work, which can also be expensive in the short and long-term. Technology transfer requires a high level of commitment and expertise from both the technology provider and the recipients/owner/indigenous workforce. Intellectual talents are a decisive requirement, followed by financial resources, particularly when major contractual projects and long-term relations are involved. This literature review and methodical study endeavoured to draw previous experience of the organizations under study, including the Omani Dockyard, to understand the current situational readiness of knowledge, competencies and skills (KCS) in single- and double-loop learning. The KCS are valued by emphasising the need for force for direction, force for efficiency, force for proficiency, force for innovation, force for concentration and force of cooperation as '*a system of forces*' and also the effectiveness of training, to deliver overall Organizational Performance. The study begins by significantly and initially forming a model to introduce the determinants for the subject of study, followed by a critical literature review on ToMT and the determinants of the model. The discussion and conclusions are intended to outline the method that enhances readiness for new technology. The main contributing factors are the know-how to develop expertise and transfer KCS in the workplace. This study has determined the collaborative value of the current business to see whether future acceptance of new knowledge or technology transfer can be entertained with proficiency, perception and talents.

Keywords: ToMT; Upgrading/Alterations and Additions (As & As); '*a system of forces*'; effectiveness of training; overall organizational performance

1. Introduction

Transfer of modern technology (ToMT)/transfer of technology or technology transfer in maintenance or upgrading to developing countries for meeting certain requirement such as contractual projects tends to '*liquefy*' – '*evaporate*' fast, especially if that knowledge is to be required several years

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ahead, when refurbishment is due. Most developing countries tend to concentrate their transfer of KCS to the society in a dedicated specialisation that requires an intensive effort by those concerned to be in line with the required real-life technological situation. The candidates of those organizations who possess university or college qualifications would certainly require further training and experience to acquire the type of knowledge needed to function in such organizations. For instance, the highly technological and sophisticated platforms used in maritime trades require their own support by human talents. Universities, colleges and specialist training organizations, however, endeavour to produce industrial and commercial education for the workforce so that it is ready for the employment market and is compliant with the needs of industry and commercial organization.

The term technology transfer should therefore be employed in a manner that encompasses the constant sharing of such knowledge within organizations, to make them more viable and valuable, and this should be controlled by a specialized body from those organizations. This body would eventually assist in operational commitment and the reduction of long-term cost. That way, the organizations would be able to make those involved responsible and accountable.

Maintaining the sophisticated platforms or components of modern technological values such as ships/maritime materiel/components has never been easy. It requires not only sophisticated KCS but also constant dedication to remain available/ viable, particularly as some of the components of machinery and equipment operate for years before such expensive and sophisticated KCS are needed for complete refurbishment. Continuous transfer of knowledge through internal and external training is therefore paramount not only to cater for the number of years that platforms' machinery and components will be kept operational but also to counter the attrition of talents and bring new bodies of specialisation into the organization. The authors do not encourage docile training or a docile workforce that has to be trained in everything it does. The requirement is for organizational performance, involving force for direction, force for efficiency, force for proficiency, force for innovation, force for concentration and force of cooperation as '*a system of forces*' (Mintzberg 1991) and effectiveness of training to reduce cost and to encourage KCS management, development and the sharing, throughout the organization and beyond, to maintain the knowledge requisite for the business . The purpose of this study was to advance understanding and to make proposals in maintenance and in the material assessment of the business. There is also a need to see if such organizations have enough potential, perception and talent for future challenges and development to support changes in infrastructure and in associated platforms through maintenance, upgrading or technology transfer. Assessing and learning from the current internal efforts, outsourcing/in-sourcing and quality management of work performance are essential for the purpose of ascertaining potential performance, the knowledge of the overall organization and to establish and prepare the ground for future maintenance, upgrading or technology transfer.

To summarise, this study is intended to develop awareness of several organizations for major changes, involving the transfer and sharing of modern technology in capabilities of maintenance and upgrading. The study was conducted in the Sultanate of Oman to develop deeper awareness and it posed the following study objectives (SO):

SO1: To design a study model for '*a system of forces*', and effectiveness of training to develop a readiness for ToMT and for better dockyard, naval and Organizational Performance.
SO2: To design frameworks/models that can contribute understanding to current and future upgrading and technological changes for better dockyard, naval and Organizational Performance.

2. Critical Literature Review on Technology Transfer and its Determinants

2.1 Transfer of Modern Technology

The whole program of ToMT involves '*what and how assessment*' to eliminate all associated risks and to enhance seaworthiness conditions that meet the operational commitments. As & As is a very old term, which has been used by the British Royal Navy since the 17th Century or earlier and has been inherited by other Navies and Dockyards (Derrick 1806). ToMT, upgrading or As & As and all other terminologies involve technical knowhow, which is a paramount part of the process or change for an organization, dockyard or the total navy to remain significant and efficient. Kelli et al. (2013) explain that ToMT, in a country that relies on 'natural resources such as (oil and gas – land and minerals)', is insufficient for organizational reliability in a country that does not describe economic activities as 'intellectual resources', involving know-how and expertise. ToMT therefore, refers to the flow of "hardware" and "software" elements of technology, that is, equipment, methods, procedures, information, and know-how, from one agent or organization to another, for further operations and development with the objective of mutual benefit (Gottwald et al. 2013). Brooks (1966) defined technology

transfer as a process of diffusing science and technology through human developmental activities. Additionally, Krentsel (2008) explains that technology transfer is the process of exchanging, transferring or finding knowledge, competencies and skills (KCS) for the purpose of commercial or operational development.

2.2 Challenges of ToMT

Challenges to technology transfer can be many, including the values of science and industrial culture, difficulties of learning and assessing new technologies (Forouhar et al. 2016). Challenges to the transfer of technology are related to human resources and information (Forouhar et al. 2016). However, ToMT is not a total solution. There must be rejuvenation and reiteration in the area of methodology by designing appropriate frameworks/models to involve the workforce and to continuously revisit the intended processes for an enhanced technological innovation (Williams 2001; Liou and Chen 2011; Al-Raqadi A. M. S et al. 2015). The methodology for technology transfer consider the difference between knowledge exploitation and knowledge exploration, where the former is more concerned with the real technology for the key business and the latter is more concerned with strategy, change, and reorganization of the core business as a result of technology transfer, prioritising and monitoring strategic issues (Bryson 2004).

As a case example of technology transfer in Asia, difficulties were experienced in an area of collaboration to enable a more multicultural working environment to develop competencies. This has been virtually impossible in some countries such as Japan and China (Hirst et al. 2011). Technology transfer to the Arab world, particularly the Arab Gulf States, where some of the challenges or issues that are not completely defined, requires clear awareness of the value of information to be digested by the indigenous organization in order to avert complex issues (Al-Mabrouk and Soar 2009). It is therefore important to contend that technology transfer between two organizations with different geographical areas, different languages and different cultures requires careful early preparation and agreement, especially in the area of the language of instruction, preparation of operational manuals and cross cultural requirements, so both organizations avoid unnecessary barriers (Hirt 2012). Culture is related to what we have, think and do, involving environmental/personal behaviour or surroundings, relations and their way of life (Baporikar 2016).

Technology transfer for major projects therefore, requires very early preparation to build a lasting partnership, particularly for major and prolonged naval or maritime projects. This avoids unnecessary frustration, which can be retrogressive without a constructive policy, or without strategic planning and implementation supported by frameworks/ models and processes (Samuel 1971; Keller and Chinta 1990). Technology transfer for sophisticated maritime platforms is subject to a contractual agreement for a supply of knowledge to the customer in need of common understanding. It is worth stressing that technological knowledge tends to '*liquefy*'/'*evaporate*' fast due to the sophisticated movement of those involved and the time required before actual knowledge is needed for certain support of ships/platforms, or for the repair and maintenance of maritime materiel.

Technology is designed with certain objects to form certain functions to inject certain knowledge, competencies and know-how skills of workers (Gottwald et al. 2013). When procuring modern technology, some efforts have to be made by the client or recipient to also acquire 'source codes' with comprehensive descriptions that can be interpreted into machine language known as 'object codes' (Grubb and Takung 2003). Maintainers require not only software but also 'source codes' and 'object code' to maintain effectively. They also require an understanding of various design, system and user manuals for machineries, components and system interaction, documentation of all types of program, including analysis, specification and procedures for software system operation (Bennett et al. 1991; Grubb and Takung 2003). The client and associated practitioners have to be trained to enable them to carry out in depth integrated maintenance and operation at different levels for better and overall performance of the whole system.

Ships, maritime materiel, infrastructure or platform maintenance can be very tedious and monotonous. It requires the competent delivery of effectiveness of training, components of '*a system of forces*' and overall Organizational Performance with proved reliability, validity and normality (Al-Raqadi A. M. S et al. 2015). This can allow the organization to build a knowledge-based relation with the industry and within the organization through the investment and reinvestment of the competencies of dedicated workforce skills (Rizzo et al. 2011). When dealing with sophisticated units such as those of maritime materiel, infrastructure and platforms, there must be a method for endeavouring to function as major industrial and operational units and the whole process must be in-line with the world and readily prepared for new technology transfer. However, organizations that are subject to, and directly affected by, the transformational environment must participate in the continuous maintenance of '*a system of forces*' supported by effectiveness of training for overall

Organizational Performance through effective knowledge/technology transfer. Basically, technology transfer of tangible assets, knowledge and capacity from one organization or individual to another for the purpose of enhancing the process involves things such as the ability to operate and maintain (Gottwald et al. 2013). ToMT or even dealing with current technology is not without challenges, particularly those involving the capability of the provider to transfer the new or support the old knowledge to/for the recipients, and this process can sometimes be complicated by the superimposition of cultural values (Hirt 2012). The barriers and challenges to maintain old and to accept new technology can mostly be in the area of tradition and the value of science; priorities and industrial cultures; impact; adoption and difficulties of understanding and acceptance of technology; lack or shortage of expertise in the field; delays caused by bureaucracy and hierarchical disciplines that result in rigidity, mainly caused by complex rules and regulation or by lack of awareness, particularly in the area of research and development (Forouhar et al. 2016).

2.3 ToMT and Organizational Performance

Organizational performance can be enhanced in a professional manner in the areas of effectiveness of training and the components/determinants of '*a system of forces'* (Mintzberg 1991; Al-Raqadi A. M. S et al. 2015). Overall organizational performance is the outcome of overall effort and it is responsible for the acceptance of new technology transfer. Experience, however, reveals that preservation of professional performance can easily be hampered by an organization within that organization's norms and regions, which can be due to budgetary control that immediately affects the overall technical proficiency of major projects (Feller 1987). The organizational performance under discussion requires the organization's practitioners to be aware of commitments, organizational policies and business practices, frameworks, and processes to sustain the knowledge transfer and required performance. Corporate governance remains a very important issue in any organization that seeks ToMT to improve performance. The emphasis should be concentrated on the changing nature, such as the transformation of individual minds, behaviours, actions and the alternatives to systematic operation through '*a system of forces*' and effectiveness of training, involving both vertical and horizontal changes to improve performance (Mintzberg 1991; Gottwald et al. 2013). This study accommodates a critical literature review and research, with the intention of developing a better outcome for changes through ToMT for better performance.

3. Methodical Discussion and Conclusions

3.1 ToMT of Ships, Maritime Materiel and Infrastructure

Technology transfer of new products such as maritime materiel or ships and support infrastructures that are required to continue their operation during the course of their life cycles, involves procurement or acquisition of not only a product but also of know-how and the associated techniques of new technology. The whole evolution of technology transfer requires careful preparation and a milestone plan for the total life cycle and methods to enhance the management of technological changes insisting on force for innovation and the other determinants outlined in Figure 1. Technology transfer requires a contractual agreement such as a partnership between the client/owner and the provider; appropriate and qualified manpower, external organizations, (involving providers of technology) and a variety of institutions and methodology (as shown in Figures 2 and 3). This can be implemented through a method of partnership for development. Technology must not therefore be treated as the only solution of solving problems and enhancing performance – some substantial structural and managerial work will need to be done long before technology is procured to enhance on performance. Technology acceptance has become a vital process, but it requires the preparation of a practice and procedure whereby the qualified workforce learn new skills and accept the modern method of doing business. Knowledge, Competencies and Skills (KCS) and other techniques require rejuvenation through effectiveness of training to build the force for proficiency to a capability of supporting the latest technology. This can assist practitioners to predict and foresee the problems of vast and diverse structures, machinery, components, electronics engineering, electronics systems and software engineering, whilst maintaining force for concentration and force of cooperation to deliver the product required for operational ships. Technology can be in the form of tools and if the workforce is conversant with '*a system of forces*' (Figure 1), through significant cooperation and concentration with technological input to continuously address all the challenges, the outcome will be increased productivity and performance. The emphasis is that to be efficient and under current modernization, personnel should engage in the utilization of technology as well as in examination of new methods of doing jobs whilst enhancing new KCS in single- and double-loop learning. In order to delimitate or close the gap, there is a need for the development of force for efficiency and effectiveness in the real field.

People should be committed to technology like Information and Communication Technology (ICT) and should share their KCS at work and continuously on the screen.

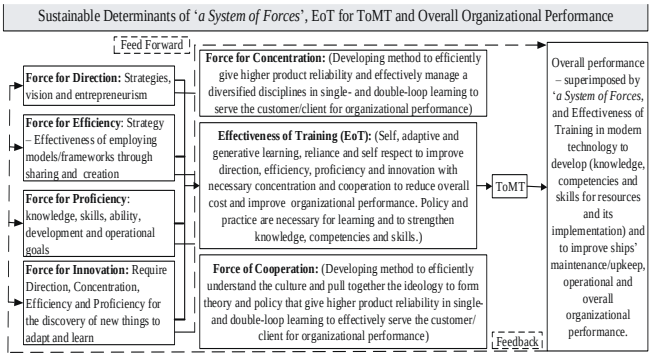

Figure 1. Typical Model of Maintenance and Overall Organizational Performance (Mintzberg 1991; Al-Raqadi A. M. S et al. 2015)

Whilst technology transfer is paramount in creating an efficient environment to participate in 'Study Objective 2' (SO2) there is a need to prepare frameworks/models, and business processes, to create a smart environment that can easily accept modernization to develop the workforce through KCS sharing, creation and application.

The whole operation requires tasks, technology and the adaptability of systems to create the required holism more effectively, with the goal of having many systems that are inter-dependent and by utilizing communication to make one system. Modern maritime technology is expensive and therefore it has to be fully utilised, particularly for sophisticated platforms that are to be fitted with modern propulsions, electronics, software engineering, control systems, communication and information technology. When procuring such knowledge, the client or recipient must make the effort not to lose control as modern technological employment can be risky, and the client has to be fully aware of how the system will function both independently, and as part of the whole process and to be fully aware of the difficulties of obsolescence issues. It is important during the total milestone plan to negate any weak areas and to solve problems through the application of system thinking. It is also important for system engineering concept tools and methods to be validated by acquisition programs, involving an intelligent workforce and a systematic and systemic perspective. Typical areas of difficulty are not knowing what you are about to negotiate, acquire or procure - the actual expectations of end-product are to understand the whole background and expectations to ensure the real structure of machinery, equipment, electronics engineering, systems and radar operation and maintenance levels to guarantee critical and long-lasting technology. This has to be done by the client during the course of research and development for procurement to eventually end up with an efficient product. It is anticipated that technology transfer through procurement of product will bring satisfactory results for diversified organizations, regardless of disciplines but it requires an early milestone plan that has to be carefully structured.

3.2 Part 1 - Hardware and Software Engineering

Part 1 forms classical areas of engineering, encompassing the architecture of hardware and software engineering, which have to be presented to the client by the shipbuilder, involving identification and know-how of a system's physical components and their interrelationship. This includes all machinery and the systematic components that are fitted onboard ship. It is a totality of all the machinery, equipment, electronics engineering, systems and radar. The architecture of such hardware requires a design model to understand the complete system and to communicate and integrate this with the architecture of software engineering. The architecture of software engineering adds understanding and behaviour of the components of an individual software system for the purpose of ending with a final complete system. The architecture of software engineering has to provide software communication to allow the development and integration of the whole. The implementation teams or the client follow this definitive work assignment, that serves as the outline for the purpose of understanding the system as a whole before the specialized training. The architecture of software engineering is the sharing of information, which shows how to integrate with each other and with the architecture of hardware engineering to establish one goal. The two architectures have to be clearly presented to the client, or the recipient of the technology, by the provider. They encompass groups of specialist and system engineers from different specialisations who design, build and integrate the whole system. The transfer of technology has to be presented in the same fashion of integration and it has to be in two areas. The first architecture is mainly the method of acquiring the technology and the second is the need for implementing the training of the practitioners. As stated in the literature review, these processes should include comprehensive descriptions of machine languages, involving machine specifications and maintenance schedules for effective operation and maintenance.

3.3 Part 2 & 3 - Levels of Training - How

The changing pattern of 'maintenance', 'repairs' and their 'definitions' have long been addressed to handle the required commitments with better efficiency (Cooke 1955). Naval maintenance training pattern for support of modern warships'

machinery, equipment and systems are normally prepared through four standard levels of training that are satisfied by the provider of technology and agreed by the client and recipient, encompassing 'operators', 'maintainers' and 'instructors' training. In **Part 2,** Operator Training involves the method of preparation and the operation of machinery and systems in general for bringing the ship or platform, or any components, into operation whilst allowing the platform to work as a whole. Also, in **Part 2**, Maintainer Training is divided into four levels. **Levels 1&2** involve onboard routine maintenance and repairs that do not require shore support, and which can be done solely by onboard staff without the assistance of depot/shore facility. **Level 3** requires in-depth shore support of major maintenance/refurbishment, involving Docking and Essential Defects (DED) and Refit, underwater inspections or complete refurbishment with depot staff support.

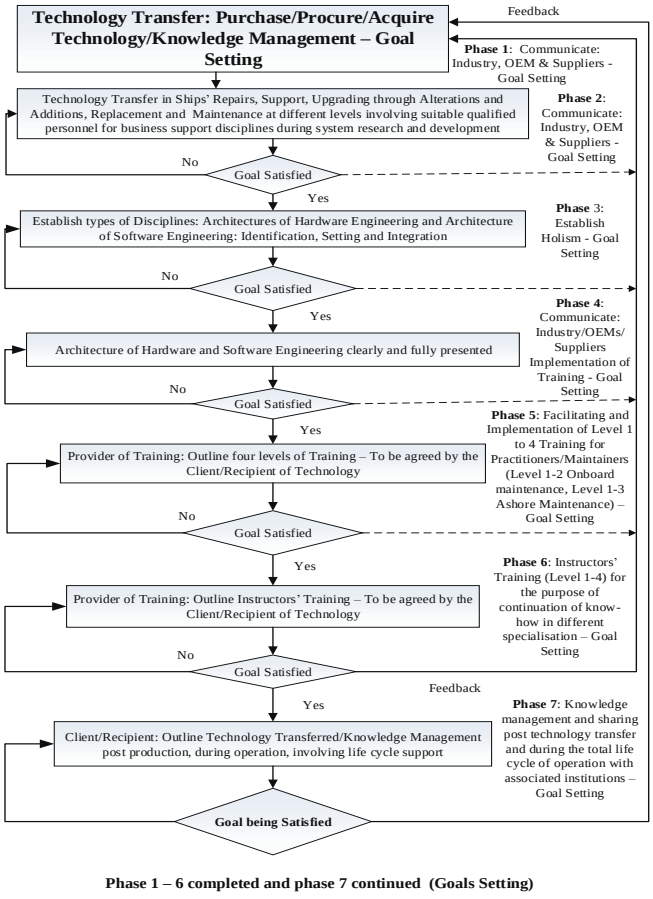

Figure 2: Framework for Integrated Support Process of Technology Transfer and Knowledge Management of Ships Repair Operation in a Disciplined Environment

It should be noted that normally the provider will tend not provide such training to ensure that a monopoly is maintained, and that limited technology transfer is done. This is where the client must insist on long term self-reliance and this has to include **Part 3 - level 4 -** the instructors' training. The instructors' training is created specifically to ensure a continuation of know-how/KCS in the organization. Instructors, depending on their specializations, will receive comprehensive training for continuation of knowledge, competencies and skills. The instructors will be responsible for reinvigorating such concentrated KCS to their own people back at home and for ensuring that the know-how remains, or is upgraded, within the organization during the project life cycle. **Figure 2 above and Figure 3** outline a typical example of technology transfer and the management processes when technology is purchased by the client, or recipient, and the knowledge management necessary for the total life of the platforms.

In conclusion, technology transfer requires the support of a critical design of the whole model from inception to completion. It has to be strengthened through effectiveness of training to develop innovation, cooperation and the concentration of practitioners who have to be arranged and managed in groups of disciplines for efficient and successful KCS transfer. For instance, force for innovation is a difficult determinant, which requires further and constant research. It involves methods of questioning, discovering, generating and developing new KCS to maintain and operate ships economically. The success of technology transfer will depend on the technological innovations that were carried out.

The procurement of new naval platforms and their associated support can involve major challenges in the areas of KCS. The stumbling blocks to the implementation of technological innovation that could be experienced by the ship owner - client are that its design might not have received enough testing and trials to prove its reliability and constancy of availability. effectiveness of training should continue even during the operation and support mode to cover the total life cycle of the ships/platforms through employment of client instructors to generate technical and managerial competencies for better and overall performance. Continuous training has to aim at enhancing those technical and innovative elements that requires an extended period to develop learning and expertise. It is important that technology transfer from the external and commercial organizations to the public dockyard/maritime/naval organizations is effectively undertaken and is shared with other associated institutions within the Sultanate of Oman. Collaboration between public organizations and external institutions in Oman, including universities, colleges and maritime engineering organizations with academic organizations is important. It allows a culture of sharing such knowledge to be introduced to the new generation in preparation for facing the future. Specialist technical personnel such as instructors

from maritime organizations, who have participated in intensive training from the original manufacturers' can be used to internally reinvigorate such knowledge. They could also be used to give introductive/inductive lessons to other external associated organizations within the Sultanate of Oman to inspire and allow for the preparation of future generations. The whole process is needed to demonstrate to future generations that work practice can be strengthened. This is probably best accomplished by experienced professionals/instructors who can share their knowledge and expertise and use open technology transfer in both the parent maritime organizations (the dockyard and the navy) and in the wider Omani society.

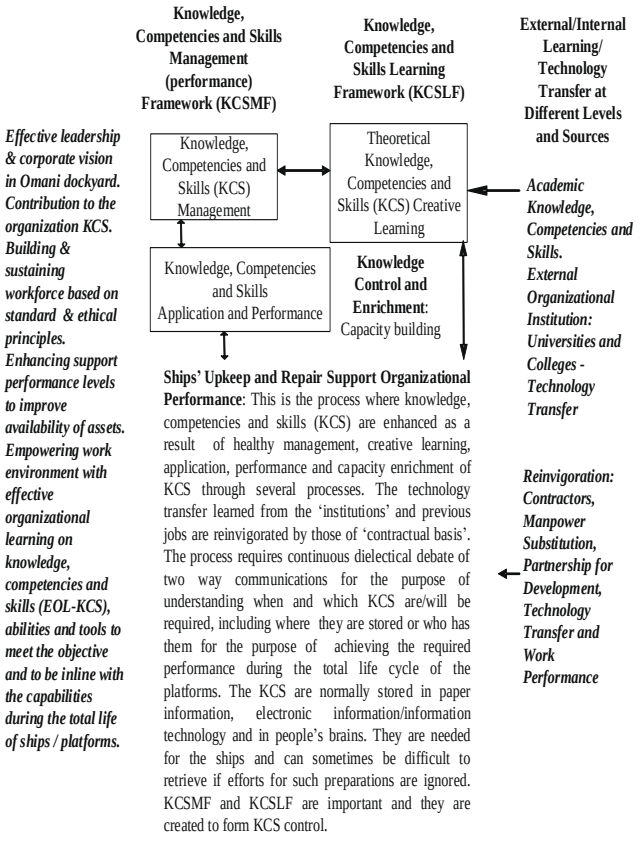

Figure 3: KCS Management and Creative Learning Framework (Al-Raqadi A. M. S. 2016)

3.4 Limitations and Delimitations

Whilst some intensive works on technology transfer have been reported in the literature, there appears to be a gap/limitation in the method of technology transfer to developing and disciplined organizations for different applications. The literature has been found to be too theoretical, with almost no realistic studies addressing the difficulties that are being faced by the real/ developing/developed world. It must be understood that technology advances faster than the build program of ships, leading to the dilemma of obsolescence issues in equipment before the completion of projects. This can create difficulties for all parties. For instance, some technologies that are requested by the client/customer, such as Source Codes/Object Codes, which tend to be difficult to implement due to in-country capability of the customer are exacerbated by obsolescence issues. Equally, the technology provider and client/recipient for organizations in different geographical areas, with different language and cultural backgrounds, can encounter many difficulties. Delimitations are required through a process framework to be thoroughly and carefully prepared to alleviate such dilemmas, in the interest of both parties. Delimitations should also be made through investigation and the involvement of all parties to address the foregoing difficulties and to assist in creating readiness based on '*methodical principles involving a working together of all parties'*. This would enhance readiness of technology transfer. The study used methodical discussions and conclusions to address the gap, particularly in the Sultanate of Oman. The study is also supported by a model (Figure 1) and frameworks (Figures 2 and 3) to solve the problem and to offer a contribution to the body of specialist knowledge.

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