WORLD MARITIME UNIVERSITY
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E-LEARNING SUPPORT TO THE ONBOARD MARINE ENGINEER: TOWARDS AN INTEGRATED MODEL

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DECELARATION

I certify that all the material in this dissertation that is not my own work has been identified and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation : **E-learning Support to the Onboard Marine Engineer: Towards an Integrated Model**

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The dissertation is a study of the emerging e-learning model and its applicability to seafarers in general and marine engineers in particular as a means of providing distance education support from shore-based Maritime Education and Training institutions.

E-learning is shown to be an integrating conduit that can combine both contents and delivery of distance education. In this process, e-learning enhances the outreach, connectivity and interactivity of the hitherto disparate elements of IT (Information Technology) driven education tools such as multimedia, simulation and Computer Based Training. The study presents an overview of the ongoing research and debates on the pedagogical issues surrounding e-learning.

It has been shown that e-learning has the potential to effectively support the in-service training as envisaged by STCW 95 Code. Issues specific to teaching of technical subjects and the possible ways in which they may be integrated with the e-learning mode have been discussed. The study also reports the design and developmental consideration that have gone into a model course covering a marine engineering topic.

It also offers simple tools and generic methodologies for the benefit of teachers of marine engineering for: correlating onboard procedures and practices with processes; design and development of online course material; evaluation courseware; and content organisation based on the interrelationship between theory and practice.

The study lists a number of recommendation aimed at MET institutions, ship owners, courseware developers, Administrations and international maritime institutions with a view to promote integrated application of e-learning to meet the training needs of the maritime community.

KEY WORDS: education, training, marine engineering, e-learning, STCW

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LIST OF ABBREVIATIONS

CAL	Computer Assisted Learning
CBT	Computer Based Training
COL	Commonwealth of Learning
HFO	Heavy Fuel Oil
IMO	International Maritime Organisation
ISM	International Safety Management
ISO	International Standards Organisation
IT	Information Technology
LMS	Learning Management System
MET	Maritime Education and Training
NE	North East
NW	North West
OU	Open University
PDF	Portable Document Format
P&I	Protection and Indemnity
PC	Personal Computer
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
SE	South East
SW	South West
TAR	Training Assessment and Record
WBI	Web Based Instruction
WMU	World Maritime University
WWW	World Wide Web

CHAPTER: 1

1. INTRODUCTION

1.1 Industrialisation and Education

Natural curiosity about surroundings, need to understand and tame the forces of nature and the resultant necessity for learning always existed in human experience. These natural and survival-driven needs of the individual and small groups began to assume unprecedented socio-economic significance in the wake of Industrial Revolution (c.1750) and the rapid scientific and technological advancements that followed. These changes called for an altogether new series of specialisations in terms of skills, knowledge and expertise – in step with the transforming social order and the emerging division of labour. In the initial years, the tradition of apprenticeship continued to be an important method of imparting various skills and trades to the younger generation.

As industrialisation began to spread across vast geographic regions and the need for basic education and formal training came to be recognised as important inputs to development of a huge, high-quality workforce, a large number of vocational training centres and technical institutions came into existence around mid-eighteenth century in Europe and a century later in the colonies, to expressly address the development of a workforce. Many of these institutions evolved into colleges specialising in technology and engineering and universities that supported study of various branches of pure and applied sciences. A characteristic of this period was a definite shift from 'soft', scholarly pursuits in religion, classics and ancient languages by a few – to 'hard', technical and application-oriented courses attended in large numbers. In this sense, vocational and technical education may be viewed as an undertaking driven by the response of the labour markets to the demands of capital within the technological possibilities of an epoch. In the post-Industrial Revolution era, technological education and scientific research came to be recognised as the twin engines of innovation, economic growth and social change.

1.2 Advent of Computers and IT

Nearly 200 years after the Industrial Revolution, the advent of computers and their introduction into every conceivable sector ushered in, what had been termed as the 'Second Industrial Revolution'. On the educational front too, the impact of computers was felt immediately. Huge, expensive mainframe computers that only a few universities could afford to use mainly for data processing and research, appeared first in the sixties to be replaced subsequently by microcomputers or Personal Computers (PCs).

Thanks to their much lower cost, higher capabilities and their suitability for networking, it was the advent of PCs that made the computer revolution a reality. More recently, Internet access by PC networks through satellite linkages and telephone and optic fibre enabled both enrichment and tapping of information super highways and the World Wide Web (WWW). Information Technology (IT) may be viewed as the integration of information storage, database development and management, computational ability, connectivity and communications. Increasing sophistication of software has been customising IT to make the applications user-friendly. At the core of the applicability of IT to education lies its ability to hold together, the four basic elements of learning:

1) Information
2) Communications
3) Connectivity and
4) Interactivity.

1.3 Distance Education and Impact of IT

As the need for education and updating of knowledge grew stronger and extended itself to increasingly larger sections of population that were physically separated from centres of traditional learning, distance education came to be recognised as a fitting solution for linking the expanding periphery with the knowledge centre.

Beginning with the postal network which evolved nearly 150 years ago in most of the countries around the world – through radio and television – to Internet and computer-mediated education of today, distance education has been actively adopting the available means of communication to meet its goals. In fact, distance education has always been quick to seize upon the very latest means of communications, even as technology made them available. In other words, the need for distance education is underscored by its increasing outreach on one hand, and the speed of its adoption of technological advancements on the other.

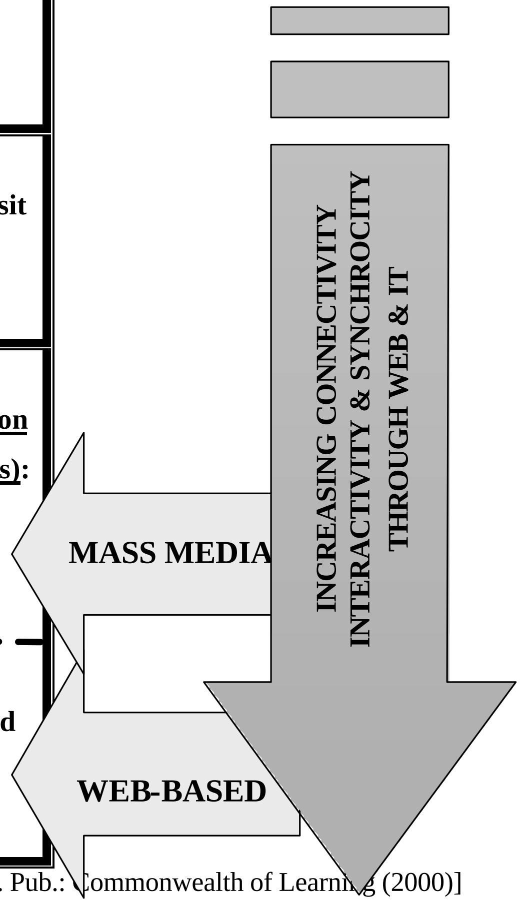
Consequent to the ongoing application of IT to distance education, a wide range of concepts such as Computer Based Training (CBT), Computer Assisted Learning (CAL), Virtual Classroom, etc., have emerged along with the related tools. For the purpose of the present study, the term e-learning has been adopted since it encompasses the whole range of electronically driven technologies employed for learning outside the physical boundaries of the classroom (Larsen & Eriksen, 2001).

Distance education is a process of imparting knowledge across physical separation between the teacher and the taught through methods and communication means that are specific to the learning process (Willis, 2000). It has particularly been benefited by the spread of IT. These benefits include:

1) *Student-led learning* as opposed to teacher-centred education; the student can pace himself and learn flexibly according to his or her convenience, time and place
2) A choice between pre-packaged material for asynchronous learning or conferencing and *synchronous* learning; or a combination of both
3) Possibility of using a wide range of *instructional materials* of different types including audio-visual contents, simulation, graphics, text, etc.
4) High degree of *connectivity* across a large number of geographically scattered students working in different time zones
5) Increased student-teacher and student-student *interactivity* that promotes active, student-driven learning; and
6) The resulting group learning that facilitates *collective* effort

An overview of concepts in application of IT to distance education is presented below in Fig.1.1:

PLACE \ TIME	SAME TIME	DIFFERENT TIMES	
SAME PLACE	Traditional classroom learning	Learning resource centres which students visit at leisure	
DIFFERENT PLACES	Radio (one way audio) TV (one-way video & audio) Two way audio (telephone)	<u>Study at home/away from academy & supported by</u>: Printed material Audio/Video tapes	<u>Communication (Asynchronous)</u>: Mail Fax
	<u>Communication (Synchronous)</u>: Chatting Audio/Video conferencing	Computer & CBT Web-based simulation	E-mail Bulletin board



[Modified from: 'Scenarios for Open and Distance Learning' (p. 6); Introduction to Open and Distance Learning. Pub.: Commonwealth of Learning (2000)]

Fig. 1.1: Application of IT to distance education: Concepts and Terms

1.4 E-learning: An Emerging Paradigm

Until the advent of Internet, Computer Assisted Learning (CAL) and Computer Based Training (CBT) existed solely as stand-alone features worked on by individual learner in isolation. Through its ever-increasing reach and the high degrees of synchronous connectivity and interactivity, the Internet has cobbled together a qualitatively superior platform for distance learning. In the words of Martin Good (2002, p.165-166),

> E-learning has crystallized an intractable issue that affected open and distance learning for many years – the question of product versus process. Because of communication technology, we now have much higher level of *process* pedagogy to work alongside and provide a context for learning *materials*. In conventional learning material and support were separate. …....E-learning seamlessly extends the reach of content, as materials can now include links to relevant websites and access to places where you 'meet' other people. The balance shifts from product to process and interaction becomes as important as content.

E-learning has therefore paved the way for integrating the all the previously developed IT-based elements of contents with delivery and interactivity functions. The application of the e-learning component to a given course could however, vary significantly, depending upon the choices exercised by the institution involved, in the areas of design and delivery.

Based on her vast experience in developing and organising online courses at Open University, UK, Prof. Robin Mason (1998) suggests three simple approaches:

1. *Content + Support Model*

   Historically, this is the earliest and most extensively used model for online teaching. It is characterised by a separation between course content and tutorial support by e-mail. Once developed, the content material can be supported by teachers other than the original content authors. Some degree of collaborative activity, peer evaluation and online assessments are accommodated by computer conferencing. Typically, the students spend around 20% of their study time online. As institutions opt for dissemination of course material on web pages, this characteristic division between content and support is somewhat blurred.

2. *Wraparound Model*

   Mason categorises this as the 50/50 model in which, tailor-made materials (study guide, activities and discussion) are wrapped around existing materials (textbooks, CD-ROM resources or tutorials). Online interactions and discussions take up about 50% of the students' study time. Compared to the content+support model, this model tends to be more student-centred. The role of the teacher is also more extensive since he or she is expected to devote more time to organising, directing and monitoring of the online activities.

3. *Integrated Model*

   Located at the opposite end of the spectrum, this model emphasises most on collaborative online activities. Since the individual learner is free to explore, the course contents are fluid and dynamic. More significantly, the integrated model dissolves the distinction between content and support. It is predominantly technology driven and largely student-centred. The teachers are required to provide a rich, interactive environment for the students to explore and engage fruitfully in, spending almost 100% of their study time.

Mason's classification not only provides an overview of the evolutionary growth that has been taking place over the past decade in the area of online teaching, it also highlights the fact all online courses need not necessarily be organised on the same lines. 'Horses for courses' seems to be best approach.

It may be noted here that the terms online teaching and e-learning have been used synonymously in this study since the application of Internet is the unifying feature.

1.5 IT-enabled Distance Education: Key Issues

Quality

Effectiveness of a distance education course can be measured in terms of its ability to meet the learning objectives and this approach is in accordance with the widely-accepted definition of quality as 'fitness for purpose'. Garrison (1993) however, suggests that it is important for the distance educator to be fully aware of the ingredients that go into the 'process' that contribute to the quality rather stopping at the 'product' as judged through assessment and student feedback. Whether or not enabled by IT, the key success factors in distance education process are: accessibility, clarity and directness of the courseware, timeliness and contents of response to requests for clarifications and access to fellow learners and reference materials. Provided it is integrated appropriately into the teaching process, Information Technology is capable of enhancing all these factors (White, 2000). As institutions offering distance education continue to proliferate, attempts are being made towards self-regulation. The Commonwealth of Learning (COL) has developed a useful guide for the students on choosing a distance learning provider and a code of conduct for the institutions. COL identified the student's computer literacy to be an important entry-level factor that can significantly influence the quality of interaction and the dropout rates.

Accessibility

The importance of accessibility and caring was recognised long-before the Internet era. Rumble (2000) reports that the remarkable success of UK's Open University (OU) can be attributed to three factors: excellent teaching material, efficient logistical system and high quality student support. OU developed a counselling service through a named counsellor with the objective of providing what was termed as 'continuity of concern', which extended to the non-academic areas as well.

Technology: Current Options and Limitations

Researchers recommend that teachers venturing into online course development should first survey the existing courses and their management (White, 2000). Increasingly sophisticated but user-friendly Learning Management Systems (LMS) such as WebCT, TopClass, and Blackboard that facilitate development and management of online courses are available today. Tooth (2000) recommends that 'why' questions must be raised when making technological choices and the cost- and time-effectiveness need to be weighed against the educational reach. The primary objective, according to him, is to open up greater learning opportunities.

Highly impressive course materials are being prepared today and presented largely through multi-media. But the speed of data transmission continues to be the chief bottleneck (Ailing, 2001). The gains in speed of transmission using fibre optics that represent the best option today (Muirhead, 2000), are not within the reach of several countries. The distance educator therefore has to reckon with the twisted pairs of telephone lines in many situations while developing his online courses. Following his study of obstacles faced by online teachers, Bonk (2000) reports that the development of CBT courseware is a collective process, which at the same time, is highly time-consuming.

Pedagogic Issues

Tooth (2000) cautions that technology is a servant, not a master and media is not the message. Shale and Garrison (1990) contend that distance education is more about 'education' rather than 'distance'. Garrison (1993) describes the process of education as assistance for independent constructing of meaning, which is to be undertaken in an interactive environment where 'concepts are offered, challenged and acted upon…paradoxically, the student can act independently for constructing meaning in a rich collaborative environment' (Garrison, 1993, p.16). Simulation, problem-solving, self-assessment and quizzing are effective teaching tools in the distance education mode because they enhance student participation (Taplin, 2000).

Instructional Material

Irrespective of the pedagogic approach chosen, active student participation is the key to successful distance education (Naidu, 1997). Mishra (2000) states that 'designing online learning requires grounding in pedagogy, and understanding of the subject to be taught and of how WWW works'. According to Swales (2000), distance education materials must take a learner-centred approach rather than the traditional, content-centred approach of textbooks. Barry Willis (2001), an educator who developed a number of useful guides on distance education, comments as follows:

> Without exception, effective distance education programs begin with careful planning and a focused understanding of course requirements and student needs. Appropriate technology can only be selected once these elements are understood in detail. There is no mystery to the way effective distance education programs develop. They don't happen spontaneously; they evolve through the hard work and dedicated efforts of many individuals and organizations. In fact, successful distance education programs rely on the consistent and integrated efforts of students, faculty, facilitators, support staff, and administrators.

It therefore appears that the development of distance education support to any specialisation or occupation is an evolutionary process. Seafaring is one occupation that is characterised by the separation of the learner from possible learning support from ashore. Furthermore, the need for in-service training has been emphasised by the Seafarers' Training, Certification and Watch-keeping (STCW) Code as amended in 1995. In the present context, it is worthwhile to examine how the need for distance education support to seafarers is being shaped and what measures have so far been taken in response to these emerging needs.

1.6 E-learning Support to the Seafarer: Needs and Responses

Need for in-service Training Support

With STCW 95 Code, which aims at global minimum standards for the competence of seafarers coming into full force in February 2002. Several seafaring nations have recently gone through a flurry of activities that included review and revamping of their maritime education systems with the intent of making it to the so-called 'white list'. Consequently, Maritime Education and Training (MET) the world over has received a new impetus. Thanks to the STCW Code, it is now being widely appreciated that training is not a one-time activity and the seafarer needs continuing education through in-service learning support (Chugani, 1997). Today's seafarer functions in a situation when the number of personnel onboard is decreasing, technology is advancing, regulatory pressures are increasing and expectations of competence are rising. Career advancement is determined by assessment systems that are focussed more sharply than ever, on specific competencies. The challenge is to ensure continuing education of the seafarer onboard where formal support and resources are lacking. Some pioneering institutions from the developed and the developing countries are already working towards this goal.

Responses from Ashore: Some Examples

Maritime Institute Willem Barentsz in the Netherlands provides continuing support to their cadets who need to serve onboard in two spells of six months each. The support is arranged through a designated member of the faculty who answers the queries of the cadets and also monitors their progress through Training Record Books. The communication is mainly through fax or mail; only cadets who are serving on cruise ships usually have access to e-mail. In India, Marine Personnel Development Services has been offering distance learning support to the engineers onboard. This is arranged either through the involvement of the ship owner or directly by the individual engineers against payment of a fee. The support is mainly through print media and the postal system. In both cases, the distance learning support was reported to be of immense help to the onboard personnel targeted. Furthermore, the involvement of the senior officers onboard and support of the ship owner were identified as essential ingredients for success (Chugani, 1997).

Educational videocassettes have been popular onboard for quite some time but are characterised by passive viewing. In recent years, with the availability of PCs on many ships, CBT packages are finding a place in most onboard training regimes. It is widely recognised now that for onboard training to be effective, it is essential to provide multi-media material that aims at a particular level (support, operational or managerial) and has a strong interactive component. Further, to formalise learning, use of such material should be a part of shore-based distance education system and expert support (Larsen & Eriksen, 2001).

Seagull (a Norwegian company involved in development of multi-media training tools for seafarers), and Tyneside College, UK, came together recently to provide distance learning support to marine engineers onboard, incorporating the CBT library that Seagull has developed. SimWeb project of Norcontrol seeks to integrate a) simulation b) collective learning and c) shore-based expert support using IT. While reporting on this project, Larsen and Eriksen (2001) acknowledge that ship-shore connectivity is the chief obstacle today and suggest that shore-based teaching and assessment in conjunction with onboard CBT and simulation is the way forward.

The Way Forward

It is hoped that ship-shore connectivity will improve in coming years making it economical for the training support to be fully and 'digitally integrated', with the introduction of more versatile satellites. INMARSAT 4 satellites have a single global beam, 19 wide spot beams and 200 narrow spot beams. The data transfer rate is expected to be at least five times that of INMARSAT 3 satellites, which cater to one single global beam and seven spot beams (Langdon, 2002). Tan (1999, p. 22) observes that '…virtual classroom afloat is not only a possibility but an emerging reality'. For the time being, 'blended learning' seems to be the solution in which, the two basic elements of distance education – pre-packaged CBT materials and (limited) online support are judiciously mixed (*Digitalship*, 2002). According to Swapp (2001, p.78), MET institutions need to 'piggyback' on the existing technological possibilities and fulfil the long-felt need for providing distance education support to the seafaring community.

Preparing for Future

At a time when the STCW 95 Code has come into full force, the power of IT – unleashed by the multi-media, the World Wide Web and the Internet – have begun to propel Maritime Education and Training towards a new domain. One can confidently predict that IT-enabled distance education support to the seafarers will become a key feature in Maritime Education and Training. Institutions and educators will need to gear themselves up to meet the changes that are currently blowing in the wind. Given the wide range of IT-enabled tools and methods that are available today, the challenge before the prospective distance educators (from an MET institution planning to develop distance education support to its students, for example) is that of making informed choices in the following areas:

1. Pedagogic methods: that match the training objectives and the targeted quality
2. Instructional material: in-house design and development or selection from what is being offered in the market; in both cases, it will be necessary to evaluate the material in relation the training objectives and technology platform
3. Technology: that supports the development, delivery and management of online courses
4. Re-orientation of teachers and institutions

1.7 Need for Research

A marine engineer, as any other seafarer, is cut-off from the resources and facilities that would otherwise be available ashore for systematic learning. When he joins his first ship, i.e., at the support level, he also finds that he is removed from the comfort of the classroom situation, which, until then, offered him learning opportunities through interaction with teachers and fellow students. He is faced with a new set of responsibilities, duties and challenges that require him to function within a well-defined hierarchy and limited social interaction. He is also required to prepare quickly for his next role as an independent watch-keeping engineer.

A rather short sea service (of six months in case of the Indian system) is now considered adequate before one can appear for the examination qualifying for this role. When he finally steps ashore for attending the 3-month preparatory course, which is now mandatory for the qualifying examination, he usually discovers that:

- He should have paid greater attention to some of the machinery and the related systems when he did have access to the manuals, drawings and most importantly, the machinery itself.
- He is unsure of many features of the ship as a whole
- Even when he is quite well-informed about the ship he served on and her machinery, he is at a loss about other ship types and machineries
- He is unable to fully relate his engineering knowledge to the working principles of various machinery

- If he happened to serve on an old ship (15 years plus), his knowledge of the current technological developments becomes very limited
- He is not fully conversant with the examination system, model papers, etc.

The 3-month preparatory course and the Training Record Book do help to overcome some of these shortcomings. By the time the engineer completes his sea service however, his priority shifts to passing of the examination. He finds that when a structured institutional support and guidance were needed most, he did not get them.

Given the recent advancements in Information Technology, communications and the increasing popularity and reach of the Internet and considering that these developments have also made an impact on modern ships, it is now possible to conceive of continuous academic support to the onboard seafarer organised by a shore-based academy. The benefits will extend beyond support at the entry level to various levels of professional growth. It is heartening to note that some attempts have already been made in this direction by a few institutions located in the developed as well as developing countries. These early attempts underscore the potential of distance education, which holds much promise in overcoming the physical separation of the seafarer from centres of learning.

Research suggests that educators embarking upon the development of IT-enabled distance education courseware are required to:

a) begin with a clear identification of the needs and the environment of their students
b) move on to an appropriate selection of pedagogic methods so as to determine the contents, learning reinforcement and assessment and
c) finally make informed and need-based choices when it comes to selecting technologies (White, 2000).

The present study seeks to apply some of the principles and practices of IT-enabled distance education to the maritime sector, targeting the marine engineer onboard in the light of the in-service training requirements envisaged by STCW 95 Code.

1.8 Objectives of the Research

1) To *identify* the educational needs, learning environment and entry behaviour of the onboard marine engineer working at the support level
2) To *examine* the methods, models and technology that are currently available for providing distance educational and e-learning support in general and to seafarers serving onboard in particular
3) To *evolve* an appropriate e-learning model that can provide the necessary educational support from a shore-based institution to the engineer onboard
4) To *develop*, as an example, contents, course plan, courseware, support methods and interaction channels, taking <u>one</u> of the topics that an onboard marine engineer at the support level is required to demonstrate competency in, as required by the STCW '95 Code before he is examined and certified to function as an independent watch-keeping engineer.
5) To *establish* guidelines for refinement of the model based on the experience gained

1.9 Methodology

1) The study will begin with identification of the educational support that an onboard marine engineer would need in his working environment in the light of STCW '95 Code and as supplementary to the scope of the Training Record Book.
2) A survey of the current debate on learning models and technology choices will be carried out to identify an appropriate model for providing the learning support to onboard engineers.
3) Contents for the model will be developed on a topic or subject, relating to <u>one</u> shipboard machinery and the connected system, namely, Fuel Oil Treatment using Centrifugal Separators which will be explained in terms of:
   i. their function and role
   ii. working principles and construction
   iii. safety of operations
   iv. environmental aspects and related rules and regulations
4) Recommendations for future refinement of the model will be listed.

CHAPTER: 2

2. LEARNING ONBOARD: THE CHANGING ENVIRONMENT

2.1 Good Practices of the Past: Destroyed by Economic Pressures

Until around two decades ago, guiding and supporting junior officers to enable them grow professionally was the unwritten code of conduct for the senior officers in most companies. The support-level engineer for example, was expected to familiarise himself with the machinery, trace lines, go through the manuals and make observations during watch and maintenance. He received guidance from senior engineers in all these activities, albeit in an unstructured manner. Most junior officers grew with renowned companies that took pride in grooming them into top-class professionals. Such companies were known for their 'best industry practices' and had an unwritten regime for induction and training. The officers reciprocated by their acts of loyalty to the owner and respect for their seniors.

The oil crises of 1973 and 1984 changed everything in shipping. Today's global shipping is characterised by: ship management divorced from ownership, flagging out, reduced manning and multi-national crews. Most operators are now not keen on recruiting support level officers. Instead, they want certified hands that can keep independent watches. Recourse to multi-national crews and the mobility of floating staff has further reduced the bonding, camaraderie and mutual support among the seafarers. Only a few owners seem to appreciate the importance of grooming the junior officers so as to eventually develop a pool of competent and loyal senior officers. In most cases, onboard training support has been put on a backburner.

Experienced maritime educators have all along been stressing the importance of a clear commitment to training by the ship owner and support from the senior officers (Chugani, 1997). Given the clearer delegation of roles and responsibilities and the ongoing changes in the regulatory regimes, it is very likely that some of the unsavoury practices of the post-1973 era will have to change in the near future. Regimes such as ISM and ISO and STCW 95 in particular, may be viewed as global responses against sub-standard ships manned by sub-standard seafarers and the ship owner's pre-occupation with operational economics. The guiding principle behind this response is embodied in IMO's motto: 'safer ships and cleaner oceans'.

2.2 Concerted Regulatory Effort

Chugani (1997, p.314) observes that:

> STCW '95, ISM and ISO are actually setting a new foundation for the management of ships for the next decade or two in the 21st century. The new system has a built-in characteristic of appraisal and review…. On the whole, the emphasis of the new regulations is on clear roles, responsibilities and accountability of training institutions, regulatory bodies, employers and seafarers (the essence of delegation).

Despite the criticism and concerns about increased inspections and paper work, there has been a general acceptance of the fact that ISM has successfully extended the responsibility for safety beyond the purview of the Master and the ship's staff to include the head office and to some extent, the ship owner. A recent study by the Swedish P&I Club has attributed higher safety awareness ashore and afloat and a marked reduction in insurance claims directly to the implementation of the ISM Code (The Swedish Club Letter, No.3, 2001, p. 1-4).

ISO auditing and certification regimes have imparted a measure of transparency and accountability to the functioning of most organisations, including shipping companies. The modified quality standard ISO 9000: 2000 in particular, places a greater emphasis on *process* rather than the *product* and on continuous improvement. It recognises training and Human Resource Development as vital inputs to organisational processes (Kushwaha, 2000).

According to Fisher and Muirhead (2001, p.91) "….time served onboard a vessel has not always resulted in trainees being provided with the practical experiences and competencies needed when starting out as a certified or licensed deck or engineer watch-keeping officer”. Further on, they state: “Ideally, the onboard training and assessment regime should be a part of the institutional quality standards system but this is very difficult to achieve in practice” (p.98).

2.3 Competency Requirements: STCW 95

The STCW 95 Code has been able to lend much clarity to various aspects relating to training, assessment and competency of seafarers. The Code envisages three levels of functioning for all seafarers onboard:

1) Support level
2) Operational level and
3) Management level

The present study is limited to the entry-level marine engineer, who functions at the support level onboard. In India, he (or she) becomes eligible to appear for the Class IV examination after putting in the necessary sea service and attending a three-month preparatory course. On obtaining the certificate, the engineer can re-join as an independent watch-keeping officer at the operational level. The targeted competence is therefore that of the independent watch-keeping engineer officer at the operational level. The STCW 95 Code offers the following general definition for standard of competence:

> The level of proficiency to be achieved for the proper performance of functions on board ship in accordance with the internationally agreed criteria as set forth herein and incorporating prescribed standards or level of knowledge, understanding and demonstrated skills
>
> [STCW 95 Code (2001), p.5]

Considering that the present study proposes to develop an instructional model around the safety, environmental and operating aspects of *one* of the Engine Room auxiliary systems, it is felt that the relevant sections of competency standards applicable for the operational level engineer from the Table A-III/1 (Marine engineering at the operational level) of the STCW 95 Code (2001, p.76-79), may be reaffirmed as follows:

Table 2.1: Marine Engineering at the Operational Level: Specification of Competence

Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Maintain a safe engineering watch	Thorough knowledge of Principles to be observed in keeping an engineering watch, including: .1 duties associated with taking over and accepting a watch .2 routine duties undertaken during a watch .3 maintenance of the machinery space log-book and the significance of the readings taken .4 duties associated with handing over a watch Safety and emergency procedures; change over of remote/automatic to local control of all systems Safety precautions to be observed during a watch and immediate actions to be taken in the event of fire or accident, with particular reference to oil systems	Assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate .4 approved laboratory equipment training	The conduct, handover and relief of the watch conforms with accepted principles and procedures The frequency and extent of monitoring of engineering equipment and systems conforms to manufacturers' recommendations and accepted principles and procedures, including Principles to be observed in keeping an engineering watch A proper record is maintained of the movements and activities relating to the ship's engineering systems

Table 2.1(Cont'd): Marine Engineering at the Operational Level: Specification of Competence

Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Operate main and auxiliary machinery and associated control systems	Main and auxiliary machinery: .1 preparation of main machinery and preparation of auxiliary machinery for operation .2 location of common faults in machinery and plant in engine and boiler rooms and action necessary to prevent damage	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate .4 approved laboratory equipment training	Operations are planned and carried out in accordance with established rules and procedures to ensure safety of operations and avoid pollution of the marine environment Deviations from the norms are promptly identified The output of plant and engineering systems consistently meets requirements, including bridge orders relating to changes in speed and direction The causes of machinery malfunction are promptly identified and actions are designed to ensure the overall safety of the ship and the plant, having regard to the prevailing circumstances and conditions

[Source: STCW 95 Code (2001, p.76-79)]

2.4 Renewed Focus on In-service Training

Circular 853 of 22 May 1998, issued by IMO's Marine Safety Committee (MSC), recalls the provisions of section A-I/6 of the STCW Convention and stipulates that the process of onboard assessment is to be carried out through a quality standard system and each ship would have to be approved as an assessment centre or be part of another approved establishment's quality standard arrangement. It is therefore conceivable that the quality standards referred to are those of, either the shipping company or an MET institution contracted for providing onboard training and assessment services.

Evidence of having achieved proficiency in certain competencies however, may be obtained from approved in-service experience onboard provided they have been assessed in accordance with the guidelines given in the Annex to the above circular, entitled 'Guidance on Shipboard Assessment of Proficiency', in conjunction with the Training Assessment Record Book (known in India as the TAR Book). The Annex itself is in three parts:

I. The Shipboard Assessment
II. Definitions and
III. An Example of Shipboard Assessment Process

Shipboard assessment (Part I above) comprises six sequential steps:

1) Identify performance objectives
2) Identify performance objectives for shipboard assessment
3) Determine performance measures and standards
4) Prepare assessment package
5) Conduct assessment
6) Develop a performance improvement plan

[Fisher & Muirhead (2001, pp.162-166). (Emphasis added)]

The guidelines stipulate that 'the first four steps above are to be conducted by shore-based personnel as part of the approved training programme in which the training record book is to be used. A qualified individual aboard a ship should conduct the assessment. The individual who conducts the assessment should prepare the performance improvement plan' (Fisher & Muirhead, 2001, p.163).

The above Circular and the Annex not only underscore the importance that IMO attaches to shipboard training and assessment; it also highlights the roles of the shore establishment and shipboard personnel. This is indeed a welcome departure from the assumption of the earlier era that shipboard experience *per se* could instil the necessary competence in the seafarer. As seen earlier, such an assumption would be over-optimistic in the contemporary shipboard environment of reduced manning, multi-national crewing and crew mobility. When the implications of STCW 95, ISM and ISO are considered together, one can clearly discern a convergence of views and the resulting pointers to the future. These pointers may be summarised as follows:

1) Importance of shipboard training and assessment cannot be overemphasised; it is the only available means of ensuring a future supply of competent officers at the operational and management levels;
2) The ship owner's quality system and procedures will have to be more exhaustive and include the onboard training and assessment aspects;
3) Ship owners, senior officers onboard and shore establishments will have to discharge their responsibilities with regard to training and assessment effectively in accordance with written procedures and show evidence to that effect;
4) The shipboard training and assessment outcomes should relate directly to the competency standards envisaged in the STCW 95 Code;
5) Shipboard training and assessment call for an integrated, rather than a piecemeal approach; and
6) All the stakeholders will need to work together towards the common goal of meeting and exceeding the global minimum standards of competence consistently.

2.5 Learning Needs

The learning needs of the onboard marine engineer are determined therefore by the gap between the competency requirements as laid down in the STCW 95 Code on one hand and the entry level qualifications, knowledge, understanding and skills on the other. Coming from a given background, the engineer is expected to meet the standards through:

1) The observations made during the service onboard at the support level;
2) The additional practical knowledge, understanding and skills that he acquires from such observations under the guidance of senior engineers;
3) Knowledge and understanding gained from a close study of the manuals and records onboard; and
4) The clarifications and insights gained from the preparatory course

This supplementing of knowledge, understanding and skills takes place predominantly within the onboard environment during the engineer's tenure on the ship. The jump from the first three steps to the last step is a significant one since the engineer is expected to not only consolidate what he learned onboard, but also to generalise it sufficiently to be able to apply to different machinery types and operating situations. He should be able to see the connections between theory and practice and the interrelatedness of the knowledge base and the skill set that encompasses the whole body of mechanical and marine engineering. From this maturation, he will be able to appreciate his future role as a competent operational level engineer keeping an independent watch mindful of safety and environmental protection. Above all, he has to prepare for the examinations and this usually becomes the primary concern.

For the support level engineer to take full advantage of his service onboard in terms of learning and preparing for his future role as an independent and confident watch-keeper, initiatives from the ship owner in ensuring a supportive environment and systematic guidance from senior engineers are essential. When properly followed, the TAR book helps to make the support level engineer's tenure onboard fruitful in terms of covering various aspect of marine engineering practice. While the TAR Book is essentially an onboard extension of workshop dairy and very useful in systematically recording ship (or Engine Room) specific learning activities undertaken by the engineer under the supervision of Chief Engineer within the limited time available, it contributes little in terms of both bringing out the theoretical underpinnings of the machinery operations and generalising the knowledge sufficiently to apply to other machinery types.

The question that remains is whether the engineer has been sufficiently primed to take full advantage of the preparatory course and demonstrate his competence to the satisfaction of the assessor, considering especially that engineers come from a wide range of backgrounds even in a single country. Let alone the global minimum standards of competency, national minimum standards are on a slippery ground. In India for example, there are as many as eleven different routes through which one can emerge as a marine engineering officer. Understandably, the teachers undertaking preparatory classes and the examining officers of the Administration who have to assess them vis-à-vis the global minimum standards of competence as envisaged by the STCW 95 Code are faced with a daunting task.

2.6 Learning Prerequisites

The entry-level marine engineer onboard who is driven, not so much by the requirements and implications of the STCW 95 Code about which he is usually unaware, but by his urgent need to:

a) quickly master the professional knowledge and skills demanded by the next level of functioning, i.e., the operational level; and
b) pass the examination and obtain his license at the earliest.

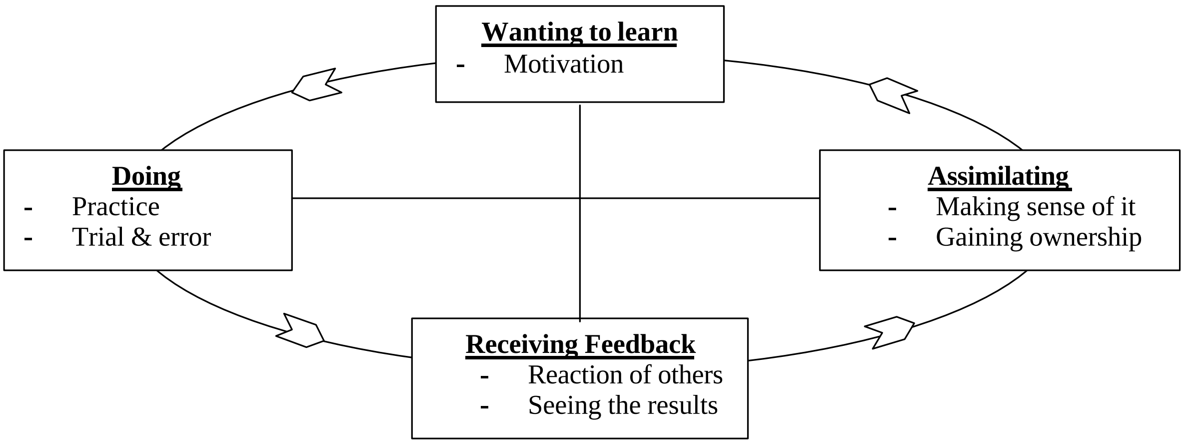
Motivation, which is a fundamental requisite for undertaking any task, especially if it is a protracted and obstacle-ridden one, springs, in the case of the entry-level marine engineer, from the two factors mentioned above. The learning process itself, should be so designed as to reinforce this motivation rather than frustrate the enthusiastic participant.

The other prerequisites are information and clarification on related issues, which will not only enhance his knowledge and understanding but also imbue a degree of confidence in himself.

He also needs a continuous feedback on how is he doing. This has to be arranged through mock tests and discussion of the results, followed by more drilling.

Finally, he needs to know where does he stand with respect to the assessment by the examination authorities. To meet this requirement, he has have access to model question and answer papers, question banks, previous papers, etc.

Any distance education support to the marine engineer onboard will have to encompass the above prerequisites. On one hand, the learning support should help the student 'discover' and *construct* meaning and the on other hand, it should *reinforce*, sustain his motivation and give him regular feedback. The following figure illustrates the interrelatedness of the four functions.



[Based on: Chugani (1997, p.312)]

Fig. 2.1: Onboard Learning Process: At the Trainee Level

2.7 Integrated Onboard Learning Environment

Fig.2.2 below highlights the key aspects of the support to onboard training from ashore from an overall administrative and organisational point of view. It envisages an integrated approach in which, the Human Resource Development (HRD) division of the ship owner's head office, the MET institution providing shore-based support and the Masters and Chief Engineers of the vessels themselves come together to accommodate and continuously support the in-service training onboard. This is done under the guidance and monitoring of the national Administration. With this approach, the training onboard becomes a collective and organisationally committed function instead of remaining an individual effort.

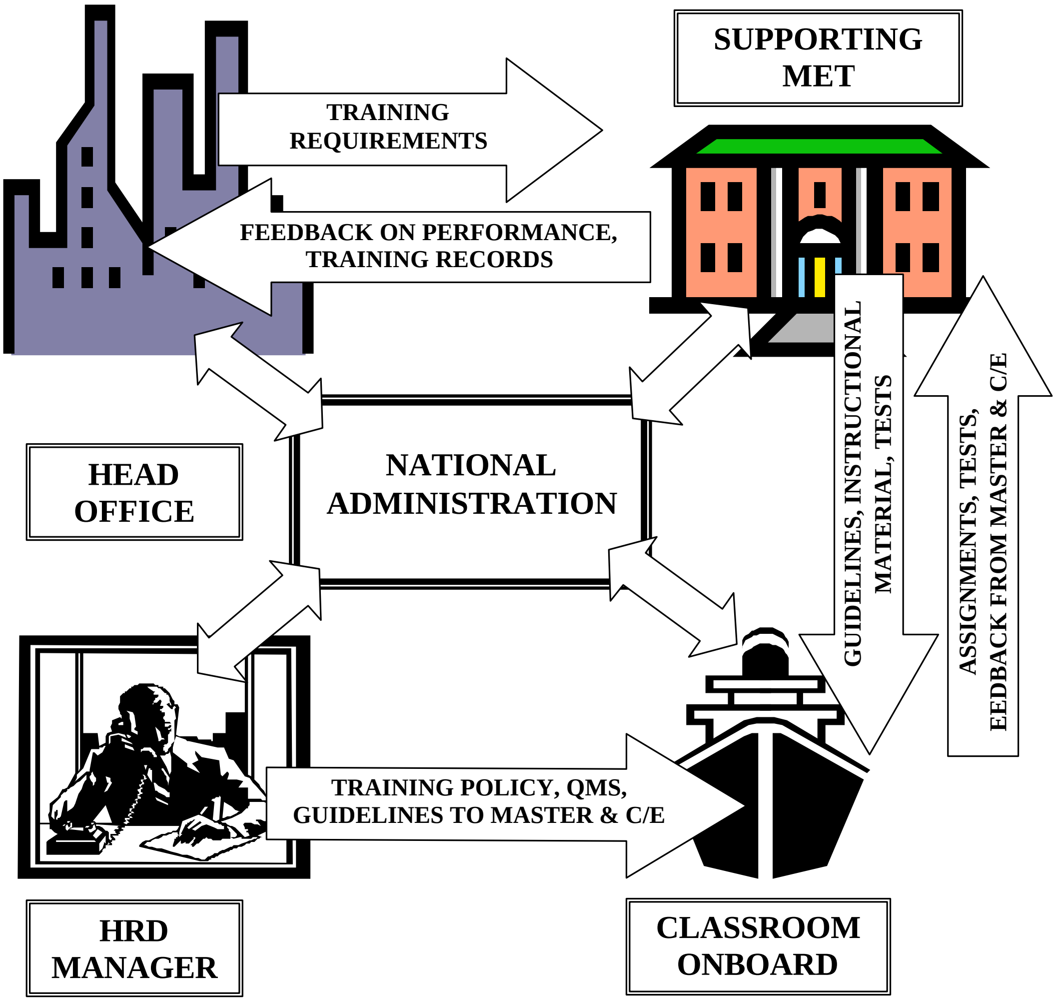


Fig. 2.2: Integrated Onboard Learning Environment

2.8 The Challenges before MET Institutions and Teachers

Considering that in the coming years, shipboard training and assessment will assume an increasing significance and shore-based MET institutions are likely to be called upon to provide the necessary long-term distance education support, the challenges that confront today's MET institutions and teachers relate to:

1) *Clarity* about objective and scope of the distance education model as applicable to maritime education and in-service training support;
2) The underpinning *pedagogic features* that shape the model;
3) Identification of the *technological options* that are best suited to the chosen pedagogic approach in terms of instructional material, its delivery and overall learning management including connectivity, interactivity, assessment and feedback to students;
4) The design and development of topic-wise distance education support within pedagogic framework using the technologies selected, without losing sight of the *interrelatedness* of topics (i.e., open architecture);
5) Teacher *re-orientation*, training and skill development
6) Institutional *re-organisation* and
7) Identification of the organic *links with industry and Administration* that are essential to make the distance education approach work.

Clarity and preparedness on the above aspects will help the teachers and MET institutions to evolve as evaluators, informed users and effective administrators of the distance learning model and emerging technologies even when they are not involved directly in the design and development of courseware.

CHAPTER: 3

3. PEDAGOGICAL ISSUES AND IMPLICATIONS FOR E-LEARNING

3.1 A Definition of Learning

According to Gagne´ (1985), a contemporary educational theorist, our major concern is to find a reasonable answer to the question: What is learning? One of the widely debated definitions is the one proposed by Kimble:

“A relatively permanent change in behaviour potentiality that occurs as a result of reinforced practice”.

Kimble (1961, p.6)

It is perhaps necessary to elaborate on the key phrases of the above definition – ‘change in behaviour’, ‘behaviour potentiality’, ‘relatively permanent’ and ‘reinforced practice’ and apply them to the current context.

1) Change in behaviour is an index of learning; successful learning manifests as changed behaviour. After taking a fire-fighting course, a seafarer may exhibit a deeper understanding and greater initiative during the drills. This is clearly an indication of changed behaviour and behavioural potentiality to respond to emergencies.
2) At times, training in itself may not immediately result in changed behaviour but will create a potentiality towards change in the individual. This potentiality can be built upon through subsequent reinforcement.
3) The relatively permanent aspect of changed behaviour refers to the permanent mark that training has made as well as its transient nature, especially in the light of changing technology and varied experience and environment that the individual is exposed to.
4) Reinforced practice refers to the importance of the trainee putting the learned concepts and skills into practice repeatedly so as to develop a sense of confidence and subsequently a sense of mastery and professional pride. In the maritime parlance, this outcome is described in terms as ‘seaman-like’.

According to the renowned educational psychologist and behaviourist B.F. Skinner, however, the changed behaviour is in itself the training and does not call for any further investigation or inference. The present day thinking among theoreticians is to emphasise the need for understanding the process rather than limiting oneself to the product. With the notable exception of Skinner, most educational psychologists agree that the changed behaviour is only the result and as such, the learning process needs to be investigated further (Hergenhahn, 1988).

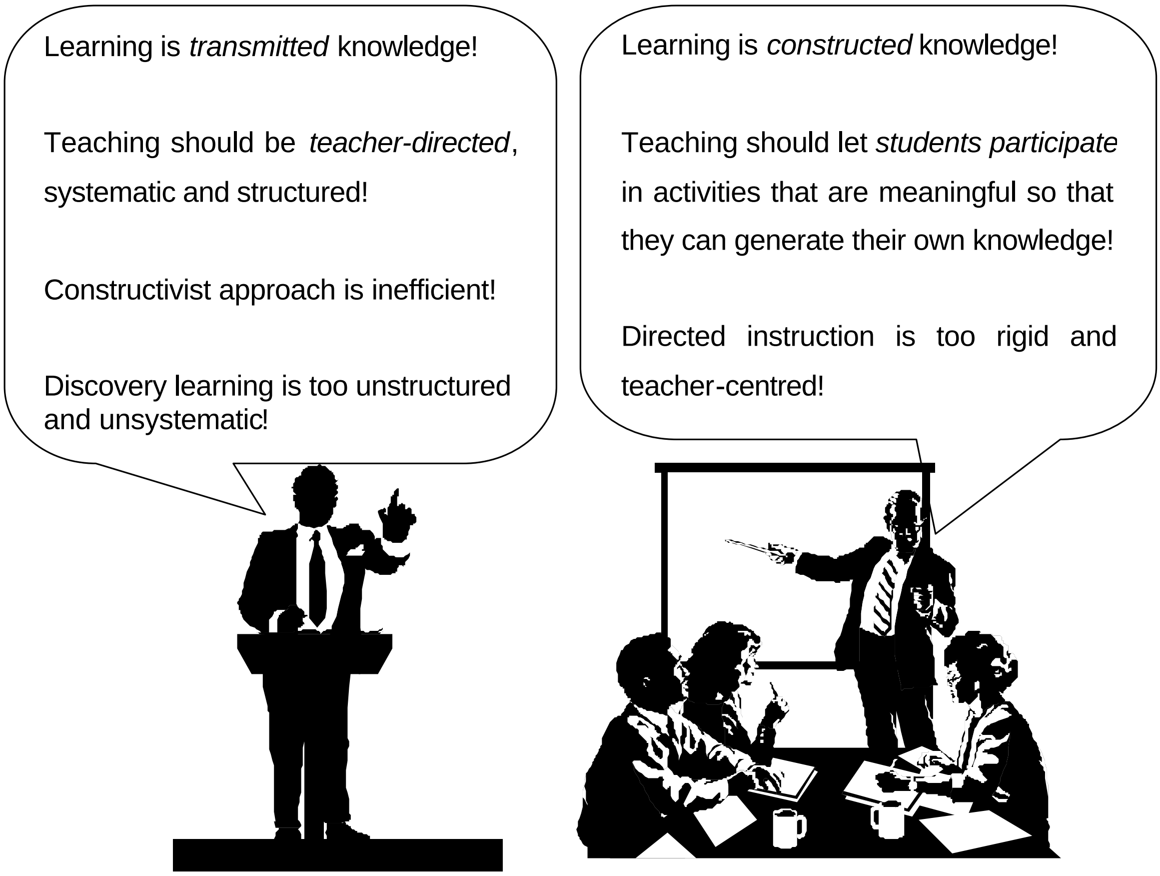
3.2 Two Distinct Schools and Implications for Distance Education

Does knowledge exist as a separate entity outside us or is it constructed in our minds? This debate resulted in two distinctive schools or approaches to education:

1) Objectivist (or directed instruction) approach
2) Constructivist approach

The objectivist or directed instruction approach has been built around the behaviourist learning theory and the information-processing branch of the cognitive learning theories (Roblyer & Edwards, 2000). The objectivist or directed instruction approach is more akin to the traditional view of education in which the teacher engages the students as more or less a homogenous group and determines *a priori*, what needs to be learned and how the discourse is to be organised. The constructivist approach on the other hand, is more flexible, student-centred and attaches a great significance to the varied backgrounds of the individual students.

Objectivists view knowledge as a separate entity existing outside the human mind and believe that learning occurs when this knowledge is transmitted by the teacher and received by the students – by means of direct instruction. According to the constructivists however, knowledge cannot exist in isolation, i.e., on its own. They believe that all knowledge is a construction of the human mind and is therefore internal to the individual, holding a special significance to each learner, based on his or her background and life experience (Willis, 1995). The difference between the two approaches is highlighted in Fig. 3.1.



OBJECTIVIST **CONSTRUCTIVIST**

[Based on: Roblyer & Edwards (2000, p.50)]

Fig. 3.1: The Two Approaches to Teaching

In recent years, however, integration of these two differing approaches seems to be emerging. Educators acknowledge the utility of both approaches and observe that it is possible to combine them in a given classroom situation so as to effectively meet the goals of learning (Roblyer & Edwards, 2000).

When the learning is undertaken in a traditional classroom situation addressing a large number of students, recourse to the objectivist directed instruction becomes unavoidable. An example could be a guest lecture in maritime law to a large gathering of marine engineers (or non-lawyers), in which several concepts would be introduced. Training on Engine Room Simulator for the same group, however, cannot be handled in the above manner. In this case, the teacher-student ratio has to be much smaller (say 1:4) and individual attention is to be paid to the trainees' needs, background and familiarisation with the software. Often, teachers are required to switch between the two approaches or take the middle path.

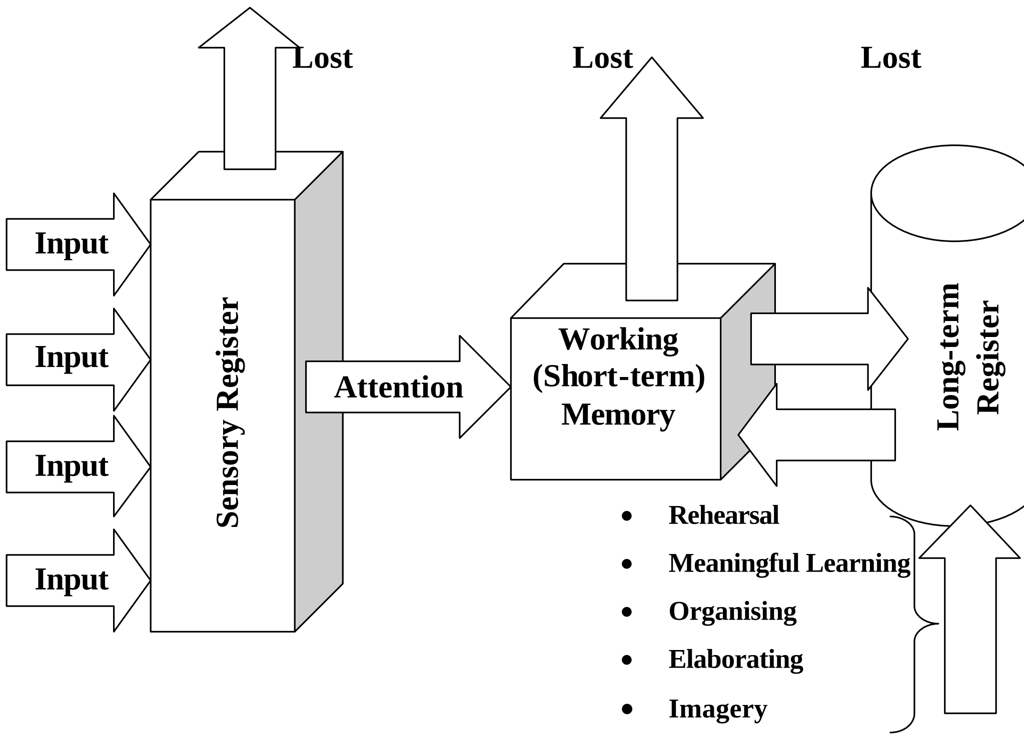
Table 3.1: Attributes of Directed Instruction and Constructivist Approaches

ATTRIBUTE	DIRECTED INSTRUCTION (OBJECTIVIST) APPROACH	CONSTRUCTIVIST APPROACH
Relationship	Traditional teacher-student relationship; students are passive recipients	Teacher is more of a facilitator in the collaborative learning process; students are the active participants
Emphasis	Transmission of knowledge	Receiving and processing of knowledge through: Participation, discovery & construction of meaning
Delivery	Collective pacing and remediation; more verbal and text-oriented. Fixed and limited set of teaching aids	Individual approach, relevant to backgrounds of participants, flexible usage of visual and other teaching aids
Flexibility	Specific, pre-determined inputs from the teacher. Efficient, straight learning path, especially for higher-level, complex concepts	Varied information and concepts that the participants can relate to their background and experience. Dynamic and accommodative learning paths
Motivation	The student is expected to be highly self-motivated and industrious	Teachers' role includes addressing motivational problems and encouraging participation
Expectations	Groups of students are expected to arrive fully prepared and carry out the assigned tasks as instructed	Each participant is guided through exercises through continuous support of the teacher who pays attention to the individual needs
Remedy	Teacher moves on at his own pace without paying much attention to the slow learners; little feedback to students	Teacher investigates changes in participation and helps to remedy; continuous feedback to participants

[Source: Author]

3.3 The Information-processing Model of Learning

The information-processing model expounded by the cognitive-learning theorists hypothesises that the human brain gathers, processes, links, classifies, stores and retrieves information, very much like the computer (Ormrod, 2000) as illustrated in Fig. 3.2.



[Ormrod (2000, p. 225)]

Fig. 3.2: A Model of the Human Memory System

While the human mind is far more complex, there are some useful insights that the above model can offer to the teachers. Effectiveness of visual inputs in combination with audio or verbal presentations, graphical representation of relationships and more recently, simulation, are well known to the modern teacher. The role that visual aids play in capturing and sustaining the attention of the class has become even more important to the teacher considering that today's generation is exposed to heavy dosages of television, videogames and computer graphics. Teachers can also assist transfer of information from short-term to long-term memory and its recall through repetition, revision, 'encoding' (practice sessions) and 'decoding' (exercises).

3.4 The Teacher's Role

Whether to adapt an objectivist or constructivist approach or a combination of both in a given situation depends primarily on the students' learning needs, motivation and background. According to Roblyer and Edwards (2000, p.52), 'Proficient technology-oriented teachers should be able to combine directed instruction and constructivist approaches. To implement each of these strategies, teachers select technology sources that are best suited to carry them out'. According to Tennyson (1990), around 30 percent of learning time should be spent on what he calls 'acquiring knowledge' and the remaining 70 percent on 'employment of knowledge', i.e., creative application and skill development. Tennyson's observation is of relevance to the basic tenet of competence envisaged in the STCW 95 Code, which is a combination of: knowledge, understanding and skills. Even if one construes knowledge as an external entity (as objectivists do), understanding is certainly an internalised process. Finally, skill development, coupled with attitudinal changes may be viewed as the targeted 'changed behaviour' as a training outcome.

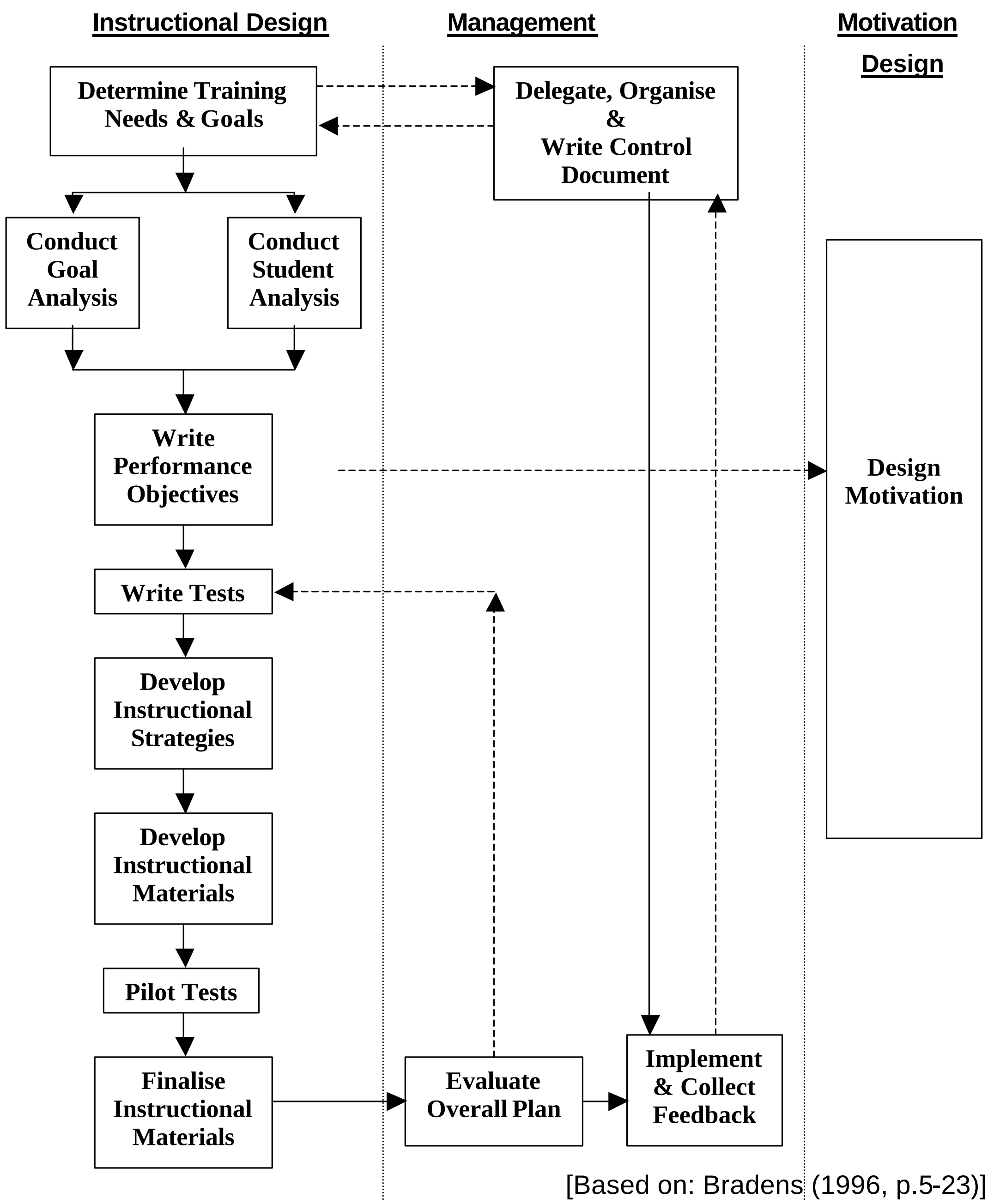
Table 3.2: Implications of the Two Models for Teachers' Role

DIRECTED INSTRUCTION MODEL	CONSTRUCTIVIST MODEL
Focus on teaching sequence that begin with lower-level skills and build to higher-level skills	Focus on learning through posing problems, exploring possible answers and developing products and presentation
Clearly state skill objectives with test items matched to them	Pursue global goals that specify general abilities such as problem solving and research skills
Stress more individualised work than group work	Stress more group work than individualised work
Emphasise traditional teaching and assessment methods: lectures, skill work sheets, activities with specific expected responses	Emphasise alternative learning and assessment methods: exploration of open-ended questions and scenarios, doing research and developing products; assessment by student portfolios, performance checklists and tests with open-ended questions; and descriptive narratives written by teachers

[Source: Roblyer & Edwards (2000, p.52)]

3.5 Systems Approach to Instructional Design

Systems approach to instructional design seeks to identify the key steps that the teacher must follow and to arrange them in an appropriate sequence. It is an outcome of brainstorming that a teacher needs to engage in before he is able to specify and sequentially arrange various tasks relating to a teaching assignment.



[Based on: Bradens (1996, p.5-23)]

Fig. 3.3: Instructional Design: The Systems Approach Model

3.6 Distance Education: Choosing an Instructional Model

Shale and Garrison (1990) maintain that distance education is more about ‘education’ rather than ‘distance’. Garrison (1993) adapts a constructivist view but at the same time, emphasises the importance of a collaborative environment in which the discourse should take place. According to Garrison (1993), the process of education is assistance for independent constructing of meaning, which is to be undertaken in an interactive environment where ‘concepts are offered, challenged and acted upon…paradoxically, the student can act independently for constructing meaning in a rich collaborative environment’ (Garrison, 1993, p.16). On the other hand, the distance learning student is also expected to actively follow the instructions given to him or her. The exercises may typically relate to simulation, problem solving, self-assessment and quizzing, which are found to be effective teaching tools in the distance education mode because they enhance student participation (Taplin, 2000). Irrespective of the pedagogic approach chosen, active student participation is the key to successful distance education (Naidu, 1997). Active student participation implies a shift from teacher-centred education to student -centred learning.

Technology can be used as a powerful tool to not only overcome the inherent inefficiencies of the learner-centred, constructivist environment but also to facilitate discovery learning, promote group activities and allow the participant to construct meaning at his own pace. At the same time, technology can support the directed instructional method through uniformity in the instructional material and improved connectivity.

Irrespective of the technologies deployed, the challenges faced by educators engaged in distance education relate to:

1) Ensuring the quality of the outcome, in line with the learning objectives
2) Sustaining the motivation of the students
3) Maintaining the logistical support
4) Catering to large numbers of students simultaneously

3.7 IT and Distance Education: Towards an E-learning Model

Information Technology (IT) has been playing a critical role in all the four areas listed above. In fact, it is impossible now to conceive of distance education without the intervention of IT. The only exception to this universal trend is that of correspondence courses that continue to play an important role in locations where the infrastructure is underdeveloped. Even in the case of correspondence courses, considerable amount of computerisation has taken place as far as the course administration is concerned.

Hereafter, distance education, which makes use of IT, will be referred to as e-learning irrespective of the extent of application. E-learning as discussed here, will encompass IT-enabled distance education in synchronous as well as asynchronous modes and application of any of the following tools and systems:

1) Multi-media and CBT
2) Computer Assisted Learning (CAL) and Computer Mediated Learning (CML)
3) E-mail
4) Internet and the World Wide Web
5) Web Based Instruction (WBI)
6) Online Teaching/Learning
7) Networking
8) Videoconferencing
9) Satellite Communications
10) Any other tool or system using electronics

It is perhaps more appropriate to adapt an integrated view of the above and the emerging tools and systems and categorise them under educational technology, while acknowledging at the same time, that computers represent the most complex tool available to humans today and Internet plays the integrating tool. Roblyer and Edwards propose the following definition: "Educational technology is a combination of the processes and tools involved in addressing educational needs and problems, with an emphasis on applying the most current tools: computers and their related technologies" [Roblyer & Edwards (2000, p.6)].

3.8 Adapting Technology to Education: Need for Caution

More often than not, institutions venture onto untried and unsuitable technologies either because it feels good to have them or because many other have already adapted them. In some cases, advanced but irrelevant technologies are accepted just because there is a donor willing to give them. It is crucial for the educators not to be carried away by the bewitching array of impressive tools that technology offers but to ask themselves the all-important 'why' question: Why do we need this technology? A number of researchers agree on this approach (Tooth, 2000). Other important questions include:

- How will this particular tool enhance our capability in achieving the training objectives?
- How does it match with the institution's goals and strategic planning?
- How does it fit into our environment in terms of infrastructure, faculty and student preparedness?
- How will it integrate with the ongoing and future courses offered by the institution?
- How cost-effective is it in terms of initial and operating costs vis-à-vis training effectiveness? How can the cost be recovered?
- Will it contribute significantly to the four functions listed under section 3.5 above (quality of training outcome, motivation of the students, logistical support and outreach)?
- What are the requirements with regard to organisational re-structuring, recruitment and faculty training?
- Given the propensity of technology for obsolescence, what is the life cycle involved and what are the investments and efforts needed for upgradation?
- Is it amenable to customisation and adding of future modules?
- Does it meet the regulatory requirements of authorities and administration?

These questions are particularly important in the developing countries where the infrastructure and support skills are less than adequate and capital and technology are hard to come by and therefore are held in awe. Satisfactory answers to these questions form the first step towards detailed examination of pedagogic and technological options relating to the 'fit' of e-learning.

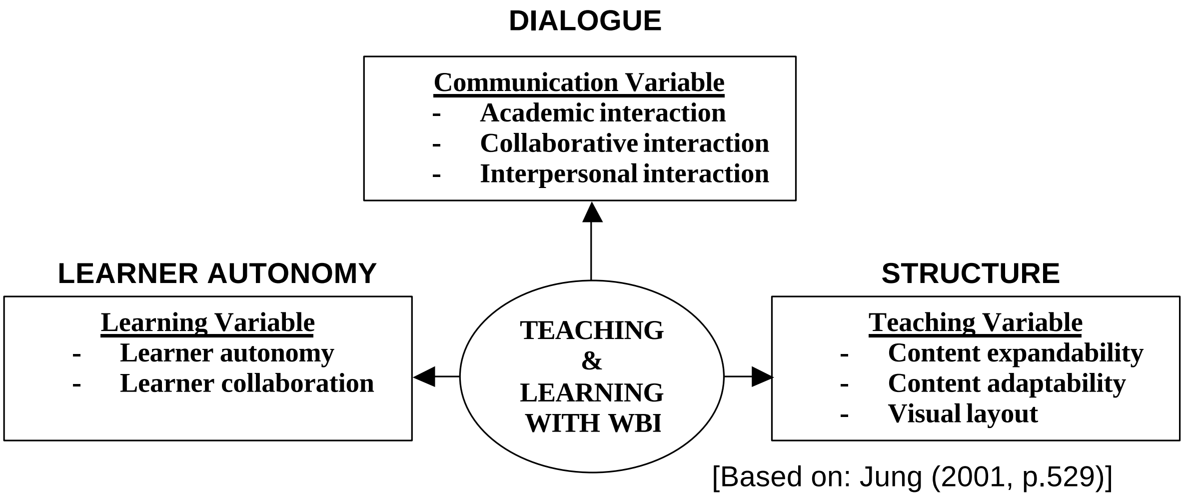
3.9 Transactional Distance Theory and Pedagogy of E-learning

Transactional distance theory – proposed first by Moore in 1972 and improved upon by a number of researchers in the light of advancements in educational technology – suggests that every distance learning situation can be defined in terms of three variables, with each one of them influencing the other two over infinite possible combinations:

1) Dialogue – Interaction between the teacher and the student
2) Structure – Responsiveness to individual needs and
3) Learner autonomy – Ability of the student to make decisions about learning and construct his own meaning and knowledge.

The goal of the institutions engaged in distance education to try and minimise the transactional distance (different from physical distance) so that the learner feels included in rather than excluded from the educational discourse. Transactional distance increases if dialogue is reduced and the structure is made very rigid (low responsiveness) and the learner autonomy becomes almost nil (except for decisions on when and where to study). On the other hand, if the structure (in terms of connectivity, instructional material and support) created is highly responsive, learner autonomy increases and dialogue can attain a higher plane of interaction. The element that the teacher can directly control is structure, through which, the other two elements, i.e., dialogue and learning autonomy can be influenced. Hence a highly responsive structure is a prerequisite for effective distance education. Teachers undertaking distance education should attend to the structure they intend to present to the learner in terms of courseware and connectivity *and* to the technological tools that enhance these constituents with the objective of building-in increased responsiveness.

Following a review of 58 recent empirical research studies on Web Based Instruction (WBI), Jung (2001) reports that "…these studies indicate that the transactional distance theory provides a useful conceptual framework for defining and understanding distance education in general and as a source of research hypothesis specifically Jung (2001, p.527)". Jung states that though the usage of the Web and the Internet represents innovation in application of technology to education, it is not necessarily pedagogically innovative. According to her, the pedagogical features of WBI can be understood from the perspective of already existing theories such as cognitive flexibility theory, constructivism and information processing theory. She observes: “Unfortunately, not many studies investigated pedagogical processes in WBI in a rigorous manner” (Jung, 2001, p.526). Design of the current wave of WBI applications seems to have been determined more by the claims and possibilities of technology than by the underpinnings of a sound pedagogy. Based on the transactional distance theory and insights that she gained from the review of current research on WBI, Jung proposes the following pedagogical approach:



[Based on: Jung (2001, p.529)]

Fig. 3.4: Web Based Instruction In Terms of Transactional Distance Theory

Jung’s findings relate closely to those of the other researchers (White, 2000 and Naidu, 1997) and the reported experience of institutions such as UK’s Open University (Rumble, 2000) with respect to the significance of the constituents of the three elements above as key success factors in distance education as well as e-learning. In addition to those listed under structure, ease of navigation has been identified as a key feature of good instructional design (Embleton, 1999). Jung’s list of constituents is therefore a good starting point for design and development of an e-learning course. Before taking up such an exercise however, it is necessary to identify the prerequisites in respect of teaching, learning, environment, infrastructure and organisation.

3.10 Applying Constructivism to E-learning

Dalgarno (2001, p.183) reports that there exist three interpretations of constructivism which have earlier been identified by Moshman (1982), and are being applied currently to Computer Assisted Learning (CAL) situations:

1) *Endogenous Constructivism* in which the individual nature of the construction process of each learner is emphasised and the role of the teacher is primarily that of a facilitator;
2) *Exogenous Constructivism* in which formal instruction and exercises that demand cognitive activity help the learner to form knowledge representation; these formulations can subsequently be applied to realistic tasks; and
3) *Dialectical Constructivism* where learning occurs through realistic experience in a collaborative situation involving peers while the teacher provides the necessary scaffolding.

In a CAL application, the above approaches can be accommodated as follows:

Table 3.3: Factors Influencing CAL Features

Type of Constructivism	Features as applied to CAL	Advantage	Disadvantage
Endogenous	Hypertext, hypermedia, simulation, virtual world	Autonomy, freedom to explore	Learners may get lost in 'hyperspace'
Exogenous	Tutorials with learner control, guided hypermedia, cognitive and mnemonic tools, exercises, help function, expert support	Can minimise wandering off, impart sense of purpose/direction	Reduced autonomy and freedom to explore
Dialectical	Group learning, collaboration, corresponding software features	Faster learning due to 'thinking aloud', debate & mutual support	Gifted learners may feel tied down by group

[Based on: Dalgarno (2001, p.183-194)

3.11 User Preparedness for using Technology in Education

Students' Skills

The skills expected of students taking part in e-learning are:

- Basic language skills (English)
- Computer fundamentals: Ability to identify hardware sub-assemblies such as the monitor, CPU, floppy and CD-ROM drives, printer, modem, etc., and their usage
- Keyboard skills and ability to log-in with username and password
- Ability to retrieve and save files including the usage of floppies and CD-ROMS
- Ability to distinguish commonly used file-types based on the extensions
- Ability to handle computer files and organise them in folders
- Ability to print documents
- Familiarity with the Internet and ability to navigate and search for information on WWW
- Ability to bookmark websites and organise them
- Ability to download information from the Web, especially PDF files
- Ability to send and receive e-mail messages and attachments
- Word processing basics

Teachers' Skills

In addition to the basic skills listed above, teachers venturing into e-learning are required to handle the following functions:

- Identify appropriate pedagogic approach inputs based on course objectives, student behaviour, infrastructure and learning environment
- Conceive overall courseware structure and key components
- Visualise screen layouts, sequencing and links; identify navigational requirements
- Create HTML pages and upload
- Moderate web-based forum and host online chat session
- Use of specialist tools:
    - Develop, organise and incorporate multi-media elements into courseware using authoring tool (e.g., Macromedia's 'Authorware' system)
    - Use of a web-based courseware development and Learning Management System (e.g., Blackboard, WebCT)

3.12 Implications for Institutions

In order to make an effective contribution to design and development of technology driven a wide range of competencies and support actions are required:

Table 3.4: Competencies for Educational Technology Users

Role	Competency
Informed user	Demonstrate ability to use computers systems efficiently for information management, presentation and communications Integrate technologies and organise contents into interrelated and manageable course-specific or overlapping teaching support packages Evaluate current instructional principles and research and assessment practices with a view to apply to own institution
In-house developer	Demonstrate knowledge of uses of media, networks and telecommunications in teaching environment Identify appropriate pedagogic inputs in the light of teaching objectives, student behaviour and learning environment for use by courseware development projects Develop channels of effective communications with courseware project team members and administrators Impart clarity of objectives to the development team and help develop procedures for planning, review and quality assurance Arrange for systematic recording and continuous improvement of technology driven teaching support tools and in-house software
Peer group, External expert	Independent analysis of feedback and evaluation of pilot projects; suggestions and recommendations for revisions and future development
Head of Institution	Evaluate the utility and application of emerging technology options, educational software and learning management systems available on a continuous basis; watch competition Develop checklists and procedures for evaluating the cost-effectiveness of technological solutions/support tools in the market Develop capability to take decisions on software procurement, e.g., buy or develop in-house?

[Source: Author]]

3.13 Lessons from Practitioners

Although the e-learning practice is barely a decade old, a large body of research covering a wide range of empirical data and field studies has already accumulated as reflected in various journals and websites. This body of research seems to be growing in leaps and bounds, especially in North America, followed by Europe. A whole new market has opened up for application of e-learning in professional development courses addressing primarily, the needs of corporate America. This is in addition to the adapting of the e-learning mode by practically every university on the North American continent (Adkins, 2001). It is perhaps worthwhile to learn from the experience of some of these path-breaking efforts.

In an era of increased awareness about intellectual property rights, one issue that has been receiving considerable attention is that of ownership of online instructional material and courseware developed by individual teachers. A study conducted by Curtis Bonk (2000) addressed this and other questions relating to the common obstacles, supports, and experiences as well as the tools used among early adopters of the Web as a teaching resource. The findings of the study may be summarised as follows:

- Extremely few respondents felt that online courses were the property of their institutions; many institutions did not have clear ownership policies.
- Compared to traditional courses, teaching online was more time-consuming.
- The dropout rate was higher in fully online courses than in partially ones.
- More instructors were supportive of bachelor and master's degrees earned entirely online but were opposed to doctoral degrees earned entirely online.
- Eighty percent of the respondents believed that accreditation for online distance education was necessary for high course quality.
- Respondents preferred online courseware that was easy to use, functional, consistent, reliable, customised, flexible, comprehensive, professional in appearance, integrated, secure, learner-centred, and pedagogically meaningful.
- All online activities (e.g., online simulations, data analyses, critical and creative thinking) were ranked as highly important by a majority of the respondents.

- The main obstacle to using the Web in teaching was identified as the preparation time required, followed by the lack of support for technical problems and courseware development.
- Faculty members at smaller institutions pointed to the need for instructional design support. Those in medium-sized institutions wanted more time allocated to learn about and utilise the Web in their teaching. Finally, instructors at large institutions needed recognition, development grants and release time.

These findings clearly point to the generally agreed observation that distance education needs to be organised differently from traditional classroom education. The report (Bonk, 2000) generated seven recommendations for instructors, administrators, and institutions engaged in IT-enabled distance education:

1) Instructor Training: Colleges and institutions need to train their faculty for online teaching covering orientation, instructional design and mentoring – taking the help of experienced universities and the early Web adopters.
2) Instructor Recognition and Support: Colleges and universities need to recognise online teaching efforts in promotion and tenure, provide release time, instructional development grants, stipends, and other forms of assistance.
3) Instructor Sharing of Expertise and Resource Exchange: Higher education institutions should create ways for faculty to electronically share services, expertise, and resources as well as mentor new faculty online.
4) Online Learning Policies: Higher education institutions need to develop clear guidelines or policies regarding: the ownership of online course materials and applicable royalties, freelance online teaching at other institutions.
5) Online Learning Research: Before adopting new policies, colleges and universities should review existing research. They might also provide internal mini-grants for faculty enabling them to carry out research and develop courses.
6) Online Courseware Development Partnerships: Rather than every large higher education institution spending its resources to develop its own courseware platform, colleges and universities should seek partnerships with courseware and other e-learning companies for new tool development efforts.
7) Online Learning Pedagogy: Higher education institutions need to research into different types of pedagogical tools that are suited for distance learning.

CHAPTER: 4

4. DESIGN AND DEVELOPMENT OF THE INSTRUCTIONAL MODEL

4.1 Course Design Consideration in Technical Education

The pedagogical aspects relating to e-learning as discussed in the previous chapter point to:

1. The need for striking the right balance between the objectivist and constructivist approaches
2. The importance of transferring the instructional inputs to the long-term memory register of the recipient
3. The impact of a systems approach to instructional design which should include appropriate motivating features
4. The need for adapting right educational technology in keeping with the infrastructure available to both teachers and students
5. Computer skills required of teachers and students engaged in e-learning
6. The significance of the structure, through which, the other two elements, i.e., dialogue and learning autonomy can be influenced
7. The advantage of learning from the experience of early web-adopters

While the above general aspects need to be borne in all cases whenever e-learning is being contemplated, there exist a number of additional considerations that are specific to technical education. In her book entitled ‘Developing technical training – A structured approach for the development of classroom and computer-based instructional materials’, Clark (1989) advocates the following approach:

1. *Pre-ordained match*:

   Firstly, she emphasises on a close, pre-ordained match between learning objectives, practice exercises and tests. In other words, reinforcement and assessment should not lose track of the learning objectives and this continuity should be evident throughout the instructional material.

2. *Advance preparation*:

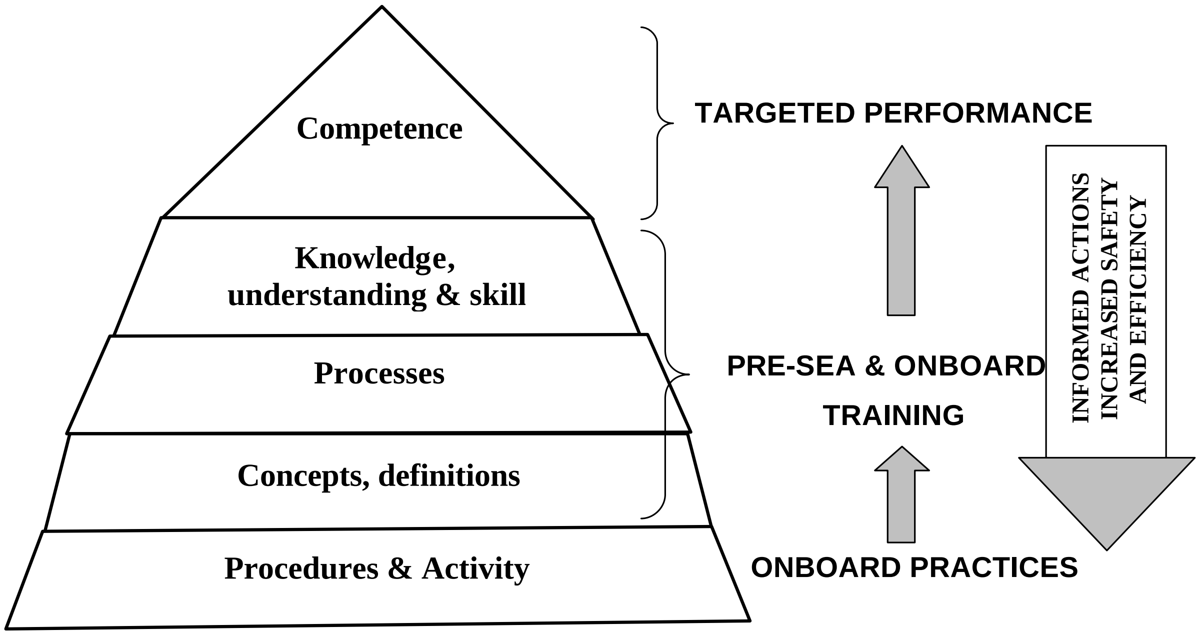
   Secondly, she warns that many technical experts turn out to be poor teachers since they make too many assumptions about the entry-level knowledge and skills of their students. In addition, the technical expert is usually not given enough time for preparation on the grounds that he knows his subject well. In a group setting, the students are too embarrassed to raise the basic questions as the teacher progresses with the lesson at a pre-determined speed. To remedy this situation, she recommends that adequate time is made available for advance preparations. Such judicious advance planning will have to include, in the language of STCW 95 Convention, 'training the trainer' and time and resources for development of the instructional material. She suggests that supportive, background technical information is built into the material, enabling the students to refer to it as required.

3. *Packaged learning*:

   Finally, according to Clark, all technical teaching seeks to address: definitions, concepts, principles, processes and procedures. She recommends that the course material clearly identifies what is being taught under each category. Clearly demarcated, manageable packages are to be delivered in an appropriate sequence. The sequence is made known to the student in advance and there are no surprises. This approach, she feels, lends clarity to the discourse and helps the students to effectively construct and retain meaning.

4.2 Teaching Marine Engineering Topics

Seafaring traditions tend to emphasise more on procedures and precautions, especially at the entry level. The junior engineer is taught dos and don'ts by the seniors and often, the entry level engineer is expected to figure out the underlying principles and processes on his or her own. This is partly because of the pressures of the onboard work environment in which, several tasks are to be carried out simultaneously and the senior engineers have little time or inclination to explain, let alone undertake formal teaching. In some extreme onboard situations, complaints are made that the junior officers and cadets are treated more as cheap labour than as future officers. It is here that the pre-sea training, integrated onboard training and preparatory courses assume significance. STCW 95 squarely addresses this issue and rightly provides for documentation of involvement by senior officers and the ship owner's shore-based management. TAR book is one such document. All said and done, marine engineering (and for that matter, seafaring) is all about practical application of knowledge, understanding and skills in a demanding and highly dynamic work environment. The challenge therefore is one of providing the junior officers with the ways and means of connecting the procedures with processes while continuing to prevail upon them to follow clearly defined procedures. The relationship between day-to-day procedures and targeted performance through competence can be represented by a pyramid-like structure:



(Source: Author)

Fig. 4.1: The Role of Training Support: From Procedures to Competence

It is the contention of this author that excessive emphasis on procedures and shipboard activities will not result in the targeted competence as envisaged by STCW 95. The onboard practice needs to be actively supported by the integrated training environment and structured instructional material so as to enable the engineer to gain insights into concepts and processes and also to direct the skill development.

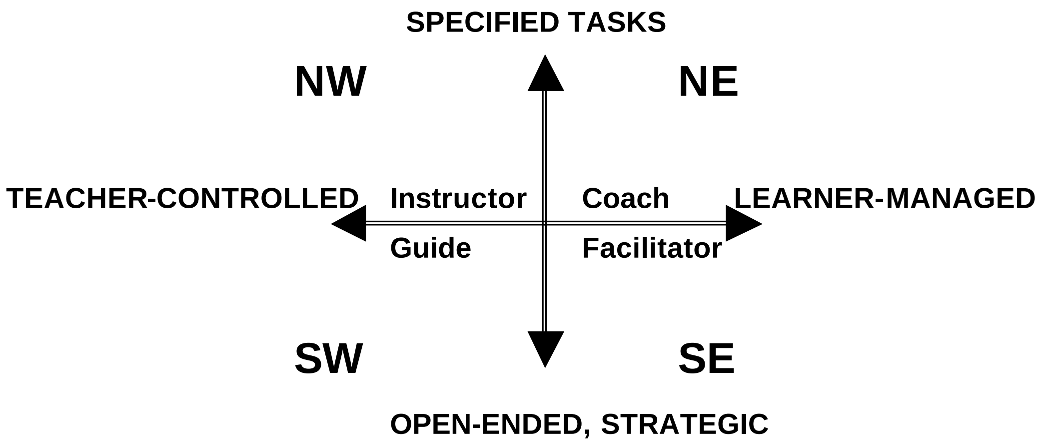
At best, excessive emphasis on uninformed procedures can lead to the engineer's performance becoming specific and limited to a particular equipment, engine room ship or situation. In the absence of adequate insights into the processes involved, any changes brought about by the dynamic work environment even in the same ship may lead to incorrect decisions and serious accidents. Teaching of marine engineering topics should therefore help the engineer go beyond procedures by:

- Providing an insightful link between procedures and processes
- Highlighting the rationale behind procedures and precautions (dos and don'ts)
- Emphasising on understanding of the underlying engineering principles and concepts in various processes
- Supplying the background information and definitions
- Serving as a building block for higher order learning and decision making

The importance of shipboard procedures however, cannot be undermined. The teacher has to be able to strike the right balance between the rigidity associated with procedures and the flexibility that constructivist learning calls for.

4.3 Teachers' Role

Coomey and Stephenson (2002) propose a grid for understanding the role of the teacher in online learning.



[Based on: Coomey & Stephenson (2002, p.41)]

Fig. 4.2: Online Paradigm Grid

Applying the above grid to the context of teaching marine engineering topics, this author proposes the following generalised approach:

Table 4.1: Applying the Learning Grid to Marine Engineering

S. No.	Targeted Students	Teacher's Role	Grid Axes	Quadrant
1.	Pre-sea cadets	Instructor	Teacher controlled Specified tasks	NW
2.	Junior engineers	Coach	Learner managed Specified tasks	NE
3.	Senior engineers	Guide	Teacher controlled Open, strategic tasks	SW
4.	Chief Engineers, Superintendent Engineers & Surveyors*	Facilitator	Learner managed Open, strategic tasks	SE

*in professional advancement courses

(Source: Author)

There are of course, a number of exceptions to this broad categorisation. Chief engineers and surveyors undergoing Advanced Fire Fighting Course for example, may suddenly find themselves in category one, deploying fire hoses hurriedly in response to the commands of a shouting instructor! Since online courses are being discussed, the above categorisation remains valid. What is of interest is the placement of junior engineers under learner managed specified tasks category. Since they have come out to sea recently, there could be an overlap between the NW and NE quadrants. The NW learning is received predominantly from the senior engineers onboard and comprises a high degree of practical work, skill development and adherence to procedures. The online courses, while targeting the NE quadrant, need to take the events of the NW quadrant into account. Ideally, NW and NE learning should move in tandem and this is achievable when the TAR books are religiously followed and the distance educations support is provided in an integrated learning environment as discussed under section 2.7.

4.4 Marine Engineering Instructional Material: A Checklist

Given the emphasis that marine engineering places on practical application of knowledge and understanding, teachers and developers of courseware should, at all stages, raise the following questions for the purpose of evaluating the instructional material and design:

- Does the material relate to a specific combination of level and function as envisaged by the STCW 95 guidelines?
- Do the course objectives match the standards set by relevant competency tables of STCW 95?
- Are the assumptions about entry-level knowledge and understanding realistic?
- Is the courseware structured in distinct modules or sessions? Are the objectives of each session clearly stated? Do they match with the overall course objectives?
- Is there sufficient connectivity and continuity between the modules or sessions? Are the notations, terminology, formulae referred the same throughout?
- Does the courseware follow the principle of moving ‘from known to unknown’?
- Is the language friendly and easy to understand?
- Does it relate strongly to the onboard work environment and tasks?
- Does it use shipboard examples and situations?
- Does it provide background information and definitions as an option for reference and recall?
- Does it make effective use of graphics to illustrate engineering concepts and principles?
- Does it state the principles and relationships in both mathematical and qualitative terms?
- Does it make use of labelled cross-sectional views and drawings to illustrate the construction and working of equipment?
- Does it make use of simulation to illustrate processes?
- Does it reinforce the concepts and principles taught by using quizzes and exercises interactively? Do these exercises designed to include answers and inform the user how he or she has been performing?

- Does material sustain the interest and motivation of the user through a rich, interactive, multi-media environment?
- Can each module or session be handled (by an average student) in a single sitting of about half-an-hour? Is it flexible enough to support a slow learner?
- Does it emphasise on efficient operations, avoidance of breakdowns and improvement of reliability through correct maintenance practices?
- Does it correlate the role of the particular equipment or system to overall ship performance, safety and reliability?
- Does it highlight safe working practices, giving the underlying rationale?
- Does it clearly state the environmental aspects relating to the operation of that particular equipment or system?
- Does it refer to and quote regulatory requirements?
- Does each module or session provide a summary?
- Does it recommend additional reading or point to other sources of information?
- Is the assessment in line with the competency requirements (for that specific combination of level and function)?
- Does it promote collective learning?
- Does it provide links to the supporting institution?
- Is the knowledge and understanding provided generic enough to be applied to a wide range of ship types and equipment makes?
- On completion of the course, is the user likely to feel more confident onboard?
- Will it help the user in doing well in the competency examination held by the Administration?
- Will it enhance the user's employability?

4.4 Practice Exercises and Assessment

Considering that teaching of technical subjects deals predominantly with definitions, concepts, principles, processes and procedures, practice exercises and assessment should aim at the following criteria:

1. *Reinforcement* of definitions and concepts
2. *Feel* of principles and relationships
3. Applications of principles and formulae to quantitative *problem-solving*

4. *Impact of process variables* on efficiency and safety; control objectives
5. Interrelationship between *controlled processes and related procedures*
6. Impact of *correct and incorrect procedures* vis-à-vis underlying processes and safety margins
7. Rationale behind *emergency procedures*
8. Relationship between proper *maintenance* and safety, performance, reliability and cost

The above criteria are examined in greater detail in the context of marine engineering functions onboard:

1. *Reinforcement*:

   Correct usage of newly learnt definitions, concepts and terminology needs to be reinforced through examples and non-examples (Clark, 1989). The student is required to distinguish between a correct example and an incorrect one (or non-example) and this will challenge the learner into applying his mind, which in turn, will improve clarity and retention in the long-term memory. 'True or False' statements are particularly useful devices in this respect.

2. *Feel*:

   The students should be made to 'feel' a relationship in his own mind, as he grapples with a principle or mathematically expressed relationship. Examples are: occurrence of centrifugal force due to inertia as propounded by Newton in his First Law when seated in vehicle and taking a sharp turn. Similarly, once the formula for centrifugal force is explained, the student should be able to guess that centrifugal force increases four-fold if the rotational speed is doubled. Exact values are not important at this stage but a feel for units is desirable. Eventually, this ability will serve as basis for quick engineering judgement, a hallmark of competent engineers.

3. *Problem-solving*:

   Ability to apply engineering principles and formulae to numbered values and arriving at correct answers and units is a routine task in the trade. The problems should always begin with the simplest cases and move on to more complex one. Most importantly, in a distance learning setting, solutions to all the problems should be made available to the student. In this context, one may recall the continuing utility and success of the famous Reed's series of books on marine engineering.

4. *Control of processes*:

   What is being referred here is not control engineering but the need for controlling a process for the purpose of optimising it in terms of maximising the benefits and minimising the risks. We do not want onboard (or in any industrial setting), a runaway process and we do have a set objectives in wanting to control each process. The instructional material should identify the targeted range of process outputs and explain why such a range is chosen and which inputs are manipulated to obtain the desired ranges of output parameters. This is exactly where procedures begin to make sense.

5. *Linking processes with procedures*:

   The logic behind procedures is made more explicit to the practising engineer. Reasons as to why we need to maintain certain viscosity of the heavy fuel oil being supplied to the main engine are more important than knowing exactly how it is done automatically, at least in the initial weeks. The worst situation is when the junior engineer is ordered by the second engineer to open the steam inlet valve by a quarter turn and everybody is happy at the end of it!

6. *Correct and incorrect procedures*:

   Having seen the importance of linking procedures to processes, it also important to make the engineer distinguish between the possible consequences of correct and incorrect procedures. All junior engineers are told to run down and open the ship's side valve before the third engineer blows down the boiler. Similarly, all fourth engineers are taught to open the manifold valve last while bunkering. An understanding about what might possibly happen if these procedures are not followed will not only increase the appreciation of correct procedures but will also discourage the junior staff from adapting dangerous shortcuts. It is not being suggested that wrong practices be tried out and consequence observed. In fact, such 'experiments' can be conducted safely and instructively using simulators.

7. *Emergency procedures*

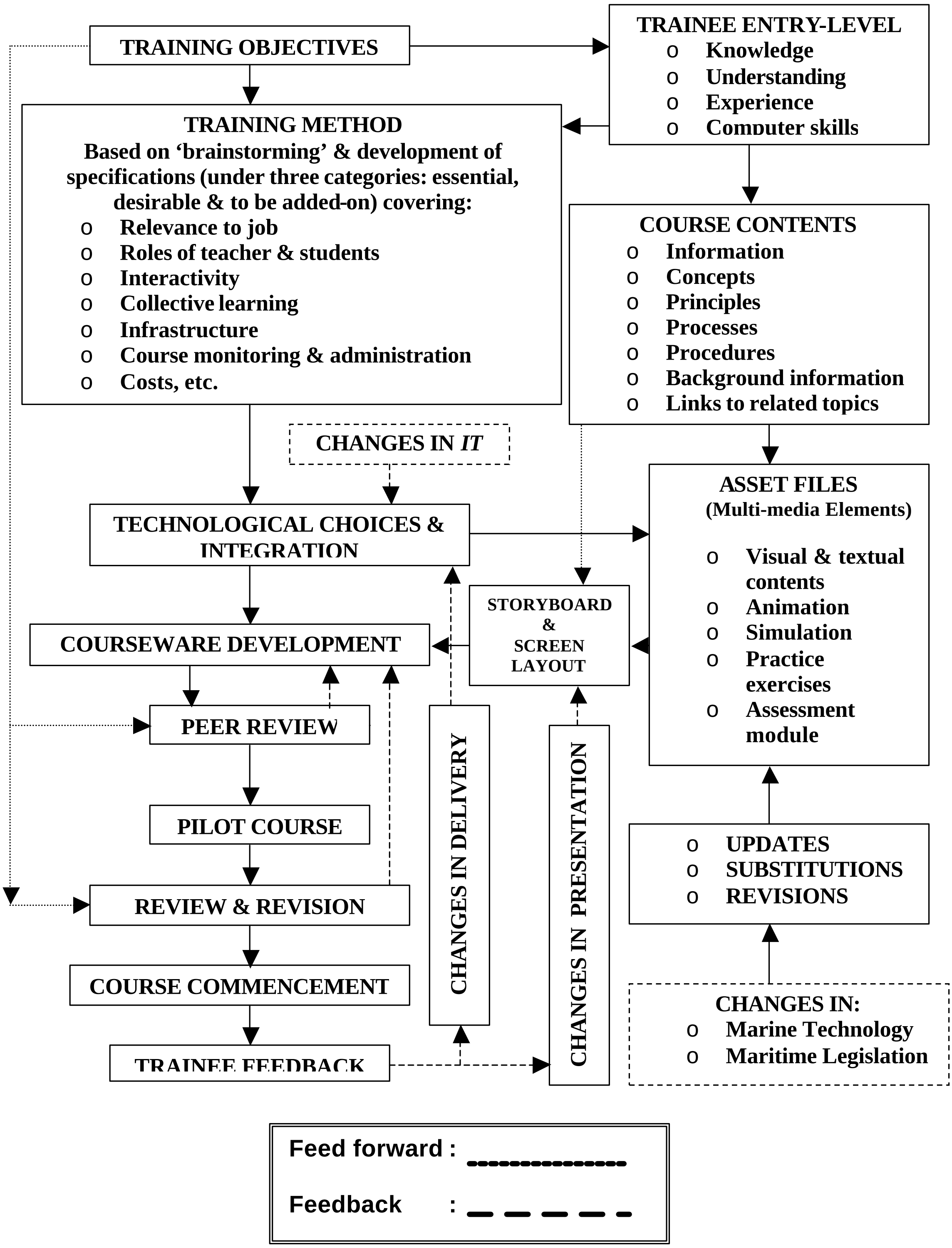
   During emergencies, extraordinary measures and actions are initiated, usually by the chief engineer. Though junior engineers may not be responsible for or involved in taking such actions onboard, awareness about the rationale behind them will help them focus on safety during watch-keeping and maintenance routines and immediately report any abnormalities.

8. *Maintenance*:

   Exercises and assessment tasks should also focus on the key elements in maintenance of equipment. These are 'hotspots' that are indicative of or causes for deterioration in performance or safety margins. Considering that modern marine equipment is operated within very fine tolerances and in a regime of increased regulatory controls, awareness about the condition of the components and their operational manifestations is vital to a conscientious watch-keeping engineer who is also engaged in supporting the maintenance function.

4.5 Technology Integration

Having considered the objectives, methods, contents, delivery and attributes of instructional material, the last question is that of technology. But for the bandwidth constraint and the cost of satellite time, we find ourselves in a happy situation as far as technological choices for courseware development and delivery are concerned. Fig. 4.3 proposes a template for design, development and delivery of an e-learning course in marine engineering:



(Source: Author)

Fig. 4.3: E-learning Courses in Marine Engineering Topics:
A Template for Design, Development & Delivery

It may be observed that the proposed template bestows a supportive rather than a dominant role to technology. The challenge however, is to integrate various technological tools that are currently available and shape them into a cohesive and cost-effective vehicle for carrying the message on one hand and to serve as a means of enhancing interactivity and participation on the other.

The approach as illustrated in Fig.4.3 takes an evolutionary view of the design, development and delivery of e-learning courses. This exercise hinges on training method, which in turn, is based on specifications evolving out of brainstorming sessions that take into account, the training objectives and the entry-level behaviour of the trainees.

Another distinct feature of the proposed approach is the subsuming of technology with respect to training objectives and methods. Once the course content is identified and technological and integrating choices concerning delivery and administrations are made, the next step is to develop the courseware. The courseware is built step-by-step, screen-by-screen based on the agreed storyboard and layout. Storyboard is the vital link between teacher and the developer and comprises hand-made sketches and information filled in standardised forms. It is the platform for visualising the content and discussing it among the development team. Even when the teacher doubles as the developer (an increasingly rare situation), storyboards lend clarity to the development process and help record the decisions and changes made along the way. Attention to storyboarding will significantly enhance the quality of the courseware in terms of visual appeal, aesthetics, ease of navigation, user friendliness, connectivity and interactivity. Once the storyboard and the screen layouts are agreed upon, the developer fills in the structure with actual multi-media content from the asset files.

The asset files, which are basically a databank of files containing text, diagrams, photographs, animation, sounds, simulation, practice exercises and assessment that have been developed around the course content and the chosen instructional method. They are the building blocks that create the sessions or modules. The modules are structured into stand-alone packages and incorporate cross-referencing through hyperlinks.

The proposed approach also takes a dynamic, life-cycle view of the instructional design in the sense that it allows for changes brought about by:

1) ongoing developments in the subject matter (marine technology and maritime legislation)
2) rapid advancements that are taking place in Information Technology and
3) improvements sought by the trainee groups as reflected in their feedback concerning course contents as well as delivery and administration.

Built-in capability to accommodate the above changes means open architecture and modularisation, which will have to be addressed in the early stages of design.

4.6 Cost as a Key Factor

That cost is a key factor for maximising the outreach of any e-learning course meant for the seafarers cannot be overemphasised. Importance of minimising the developmental cost can be appreciated when one bears in mind that vast proportion of seafarers originate from the developing countries and more importantly, they are required to fund their own training in a majority of cases. Paradoxically, the production of maritime audio-visual and CBT materials is undertaken (at considerable cost), almost entirely in the developed countries. This division goes to explain the rampant piracy associated with these materials.

Design, development and delivery of a low-cost e-learning module covering a marine engineering topic, taken up experimentally as a part of this study, will be discussed in the next chapter.

CHAPTER: 5

5. MODEL DEVELOPED

Observations under the sections 5.2 to 5.4 may be viewed as the outcome of brainstorming and inputs to practical design and development of courseware and delivery system. The specifications have been worded as if they originate from an MET institution wishing to engage the services of a developer of courseware. The remaining sections of the chapter summarise the action taken in response to the above specifications and the subsequent lessons learnt.

5.1 Topic Chosen

Onboard treatment of Heavy Fuel Oil (HFO) was chosen as the topic, for the following reasons:

- Performance, efficiency and reliability of the Main Engine depend largely on fuel quality. Modern engines operate within very narrow design parameters. At the same time, they are required to handle fuels of extremely poor quality.
- Separators are high-speed rotating machinery and call for specialist knowledge and skills for safe and efficient operation and maintenance.
- Their running hours are very long, certainly longer than those of the Main Engine.
- They do the dirty work for long hours; generate sludge and oily water that has to be disposed off in an acceptable way without polluting the marine environment.
- High degree of reliability is required of them.
- Fuel accounts for nearly 50% of the operating cost.
- Junior engineers are closely involved with starting, operation, stopping and routine maintenance of centrifugal separators.
- It is a relatively compact and self-contained, auxiliary system found on all ships that has wider implications for overall performance of the propulsion plant.
- *Definition* of viscosity and Newton's First Law can be recalled and applied.
- *Concepts* such as viscosity-temperature relationship and limiting particle size can be explained.

- *Principles* of centrifugal force and Stoke's Law and their application to separation can be explained.
- *Processes* of sedimentation and separation can be elucidated and applied to onboard conditions.
- Operational *safety* and *environmental aspects* relating to sludge and oily water disposal can be highlighted.
- Adequate information is available for developing the asset files in a short time.

5.2 Training Objectives and Targeted Outcome

The objective of the model course is to impart knowledge and understanding of the working principles, operation and maintenance of centrifugal separators used for treating HFO onboard.

On completion of the course, the students will be able to:

> Operate and maintain centrifugal separators in a safe and efficient manner, with an understanding and knowledge of their working principles, construction, operation, maintenance procedures and safety and environmental aspects.

The above training outcome is line with the definition of competence and the overall requirements laid down by STCW 95 Convention and the specific requirements listed in tables A-III/1 – Marine Engineering at the Operational Level: Specification of Competence (relevant portions reproduced in this report under section 2.3).

5.3 Entry Level

This course aims at:

1) marine engineers functioning at the support level and working towards the goal of becoming a certified, independent watch-keeping engineers and
2) marine engineering cadets in their final year.

The students are required to be conversant with the usage of computers, at least to the extent that they meet the requirements listed under section 3.11 of this report. This is thought to be a reasonable assumption since the current level of computer education in India and a number of other developing countries is fairly high both at high school and graduate levels.

5.4 Specifications

Reference may be made to the template depicted in Fig. 4.3 the points raised and discussed in the preceding chapters. The broad specifications of the model, which in turn will influenced the design, delivery and technology choices, are listed as follows, grouped under three categories, i.e., essential or desirable or capable of being added-on:

A. Essential

1. Relevance to job:

A high degree of relevance to shipboard conditions and job related activities is to be built into the course content. Engine Room terms and examples shall be introduced immediately so as to achieve a close match between the topic being covered and its practical application. Such an approach is also expected to improve motivation since participants can see the advantage of the attending the course.

2. Roles of teacher and students:

With reference to the grid proposed by Coomey and Stephenson (Fig. 4.2), the learning activity using the model may be viewed as overlapping between the NW and NE quadrants and accordingly, the teacher's role varies between that of an instructor and a coach.

Students are expected to go through the material without having to do much additional reading, answer the test and fill in the feedback form in three or four sessions of 45 minutes (maximum) each.

3. Structure:

A general introduction to the course shall precede the main body of the course material. It shall be prepared in a question and answer format, highlighting the objectives, scope and structure of the course and giving out the contact e-mail addresses of the co-ordinator. The introduction is to be presented as a power point file with a printable PDF (Portable Document File) version.

The course shall be organised in three sessions:
Session 1: Theory of Separation
Session 2: Construction of centrifugal separators
Session 3: Operation & Maintenance (including safety and environmental aspects)

Each session shall be presented in two files – a power point presentation and an accompanying printable PDF.

Each session shall be restricted to a maximum of around 15 slides of power point so that the student can go through it in a single session of around 30 minutes. The corresponding PDF file shall contain all the important graphic and textual information enabling the student to print and read at leisure. In addition, the PDF file shall contain any additional information that the student may find useful in terms of definitions and references.

Each session, i.e., the power point file and PDF file together, shall be small enough (in terms of memory space) to be capable of being copied onto a single floppy since the student may choose to carry it to another computer and work offline.

4. Presentation:

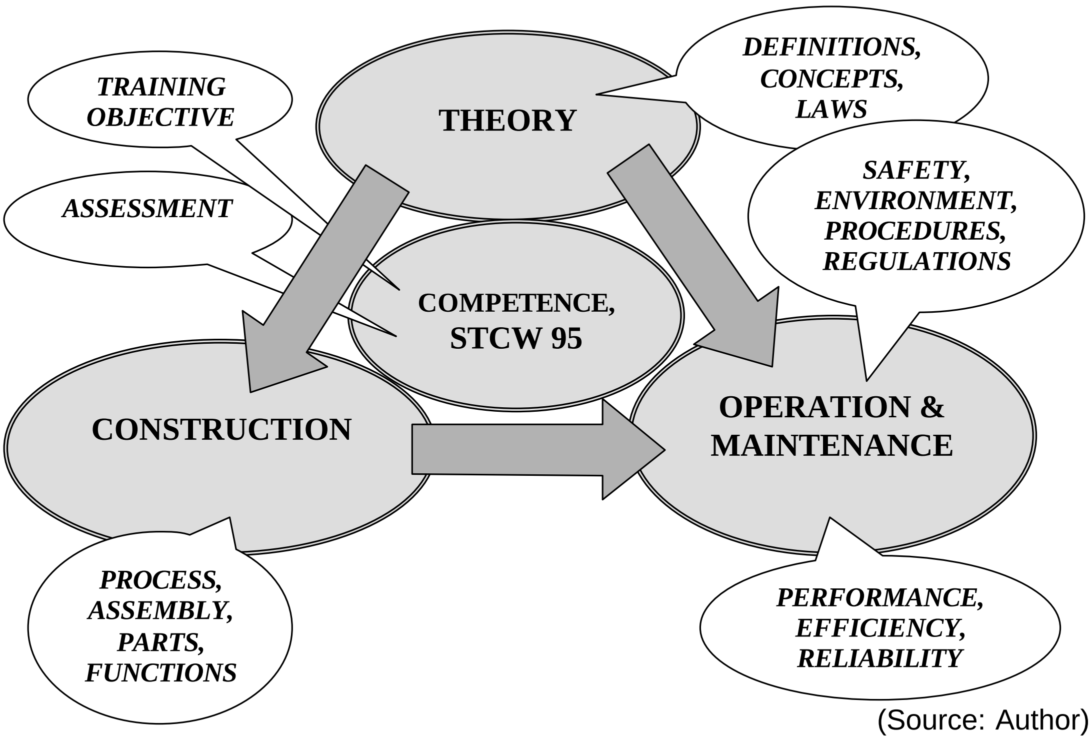
The language shall be simple and easy enough to be understood by school-level English medium students from India and the tone – friendly and conversational.

Each session shall begin with a clear statement of objectives and end with a summary. These session objectives are to be line with the overall course objective indicated above.

Consistency shall be maintained among all three sessions in terms of terminology, graphics, colour schemes, text fonts, screen layouts, notations, definitions and concepts.

When explaining the theoretical principles, practical examples (from shipboard practices) shall be used and when dealing with processes and procedures, the underlying theoretical principles must be referred. The principle of 'known to unknown' shall be adapted and complexities shall be introduced gradually.

While explaining the operational and maintenance practices, safety and environmental aspects must be stressed. The students should be able to see the connection between correct operational and maintenance procedures and efficiency, reliability and environmental protection. Fig. 5.1 illustrates the above approach:



(Source: Author)

Fig. 5.1: Instructional Design for Marine Engineering Topics: An Overview of Content Organisation

5. Interactivity:

The content + support model of Mason (1998) shall be adapted and asynchronous interactivity (student-teacher and student-student) through e-mail is to be targeted. Some of the participants may face difficulties with accessing the material from the Internet, sending attachments, etc. They should be encouraged to contact the course co-ordinator and fellow participants.

6. Costs:

The experimental model is to be developed and tried out at no cost at all. This means making use of the existing facilities and the freeware on the Internet.

7. Infrastructure:

In addition to the facilities available in most institutions and middle-class homes, a number of cyber cafes exist today even in small towns in India and access to PC and Internet is not a limitation, especially for the targeted group of students.

B. Desirable

8. Collective learning:

E-mail addresses of all the participants are to be made known to the group members and they are encouraged to contact, exchange mail and chat online.

C. To be Added-on

9. Course monitoring and administration:

In the absence of a Learning Management System for tracking the participant behaviour, the monitoring and administrative functions are to be limited to checking the incoming e-mail twice daily and answering the queries on the same day.

5.5 Technological Choices

The above specifications led to the following choices:

- Power point for courseware
- PDF for printable documents
- Creation of a Yahoo group for delivery and interaction
- MSWord documents containing test and feedback form

The specifications were closely adhered to as can be seen from the printed versions of the PDF files placed at **Appendix**.

5.6 Asset Files

An exhaustive asset file was developed comprising a number of scanned images of photographs, drawings, sketches, etc., mostly from the catalogues and manuals of

Alfa Laval and textbooks on marine engineering. A number of these images were inserted in the power point slides at appropriate places. Some images from the clip art were also used.

5.7 Course Contents

As specified, each session was begun with a statement of objectives and ended with a summary.

Session 1: Theory of separation:

The pedagogical objective of the session was to explain:

- Conditions for separation by gravity
- Stoke's Law
- Demonstration of functional similarities between gravity separation and centrifugal separation
- The phenomena of centrifugal force as a consequence of inertia, recalling Newton's First Law of motion
- Derivation for centrifugal force using Newton's Second Law
- Qualitative interpretation of the above laws to enable the student 'feel' the phenomena

Starting with gravity separation and moving on to separation occurring in a centrifugal field enabled the use of 'known to unknown' principle.

It also made it possible to give the Engine Room examples of settling tanks, their limitations and the need for using centrifugal separators onboard.

The importance of particle size, difference between specific gravities of the phases being separated and viscosity of the continuous medium – in determining the rate of separation (as denoted by Stoke's Law) was explained graphically and qualitatively.

How the rate of separation varies directly in proportion to the tank area in the horizontal plane was demonstrated graphically. Baffle plates were introduced to increase the area and then tilted (to prevent accumulation of sludge and blockage to flow of oil). The same set of baffle plates transform into conical discs of the centrifugal separator in the next step. Thus a close relationship between the theoretically developed arrangement and the actual construction of separators was established.

Graphically appealing method of first tilting and then rotating the gravity separation tank with the inclined baffle plates was deployed to introduce centrifugal separators. (This could have been done more impressively if animation could be used).

It was demonstrated that forces of very high magnitude can be developed using the centrifugal field was quantified and shown as an example (expressed as 'g'-force). All these inputs have direct significance to the other two sessions, i.e., construction and operation and maintenance as conceived in Fig. 5.1.

Session 1 was ended with a hint about what would follow in the session 2 and summary.

In the PDF version, all the above explanations were presented in a printable format. Additional information was provided with regard to definitions of absolute and kinematic viscosities.

Reed's Applied Mechanics, Chapter 5 on Centripetal Acceleration was given as recommended reading.

Session 2:Construction

After the statement of objectives, cross-section of a centrifugal separator and labelling of the key parts was taken up in steps, in the following order: from photographs to 3-D outer views to 3-D inner views to 3-D cross-sectional view. This was followed by labelled photographs of the key sub-assemblies and components in engineering cross-sectional drawings.

De-sludging action was explained using cross-sectional views (This was another situation where animation could have been more effective).

The difference between a purifier and a clarifier was explained briefly. The concept of (liquid-liquid) interface was introduced. The importance of gravity disc was explained. While giving these explanations, the drawings developed and used for session 1 were (revised and) re-used to maintain the visual continuity. Reasons for (the shipboard procedure and practice of) selecting the biggest possible gravity disc were highlighted. This explanation would serve as a firm basis for discussing it further in last session on operation and maintenance.

The centrifugal clutch and worm and worm wheel drive had to be omitted to restrict the number of slides.

Session 3: Operation and maintenance:

The advantage of running a purifier and a clarifier in series for efficient separation of water and sludge was explained schematically.

Demonstrated graphically, how the liquid-liquid interface can shift if the feed temperature is not maintained correctly and can lead to breaking of seal or inefficient separation. The role of a watch-keeping in selecting the right gravity disc and maintaining the operating parameters emphasised.

Routine maintenance actions and safety precautions listed and explained in terms of their significance.

An estimation of sludge generation given and the need for its disposal as laid down in MARPOL regulations stressed.

The session ended as usual with a summary followed by a collage highlighting the role of centrifugal separators with the caption: ‘Clean fuels…reliable engines…high performance ships’.

Finally, the course ended with the scanned image of IMO’s poster, ‘Safer ships, cleaner oceans’.

5.8 Experience gained and Lessons Learnt

The person who benefited most from this exercise of developing the model course was the author himself. It gave an opportunity to put into practice, various concepts and principles relating to design of online course, role of multimedia in training and courseware development and delivery as applicable to marine engineering education within the framework of STCW 95 guidelines.

The field trip to Alfa Laval's manufacturing facilities (arranged by WMU) helped substantially in gaining an insight into working of the separators from the design point of view. During the visit, it was also possible to collect useful background material.

The course was offered on an experimental basis to the cadets of Naval Maritime Academy, Visakhapatnam, India and Arab Maritime Academy, Alexandria, Egypt. Some of the students reported difficulties in downloading and these were sorted out. Encouraging feedback was received and most students wanted similar courses to be offered on other marine engineering topics.

Development of the asset files well ahead of course design saved much time. Initially (for session 1), developments of graphics took longer than anticipated. Speed improved in the subsequent sessions. On an average each session took around a week to develop. Even with the simple technology used, it was possible to develop a fairly comprehensive course material. The same material can be used effectively by an instructor in a classroom setting.

5.9 Limitations of the Model

It is not claimed that the model is an ideal one. The course remained basic and generic in its scope. The other limitations include:

- Absence of animation for showing the processes and liquid flows
- Reduce activity for the user
- Omission of more recent technological innovations such as the ALCAP separator or the control systems and automation requiring a separate session

CHAPTER: 6

6. CONCLUSION

6.1 Driven by the compelling need to reach large numbers of prospective learners, distance education has historically been quick to make the best possible use of the available technology. The 'second Industrial Revolution' ushered in by the advent of Information Technology in general and computers in particular, has brought about a sea change in the design and the delivery of distance education.

6.2 At the core of the applicability of IT to education lies its ability to hold together, the four basic elements of distance learning:

1) Information
2) Communications
3) Connectivity and
4) Interactivity.

6.3 More recently, e-learning has paved the way for integrating the all the previously developed IT-based elements of contents with delivery and interactivity functions. It opened up an altogether new conduit for combining the processes and the products of distance education. The degrees of application of e-learning capabilities to a given course could however, vary significantly, depending upon the choices exercised in the areas of design and delivery.

6.4 Notwithstanding the impressive technological possibilities that e-learning offers, it is the training objectives and the pedagogical methods that continue to determine the technology related choices. It is the content that determines the form and it is the process that determines the product. Technology's role is therefore secondary and supportive. The constraints are infrastructure and cost.

6.5 STCW 95 underscores the importance that IMO attaches to shipboard training and assessment; it also highlights the roles of the shore establishment and shipboard personnel. This represents a welcome departure from the assumption of the earlier era that shipboard experience *per se* could instil the necessary competence in the seafarer.

6.6 At a time when the STCW 95 Code has come into full force, the power of IT has begun to propel Maritime Education and Training (MET) towards a new domain. One can confidently predict that IT-enabled distance education support to the seafarers will soon become a key feature of MET.

6.7 The emerging perspective on maritime training envisages an integrated approach in which, the Human Resource Development (HRD) division of the ship owner's head office, the MET institution providing shore-based support and the senior officers of the vessels come together to support the in-service training under the guidance the national Administration. With this approach, onboard training becomes a collective and organisationally committed function instead of remaining an individual effort.

6.8 The challenge before the MET institutions wanting to adapt the e-learning mode is that of integrating various technological tools that are currently available to shape them into a cohesive and cost-effective vehicle for carrying the message on one hand, and enhancing the interactivity and participation on the other.

6.9 Considering that e-learning offers a potentially powerful platform for imparting onboard training to seafarers from a shore-based MET institution, it is important to understand the its pedagogical and operative aspects such as:

1. Right balance between the objectivist and constructivist approaches
2. Transfer of the instructional inputs to the long-term memory register
3. Systems approach to instructional design and motivating features
4. Educational technology to match with the infrastructure available
5. Computer skills required of teachers and students engaged in e-learning
6. Leveraging structure, to influence the other two elements of distance learning, i.e., dialogue and learning autonomy
7. The advantage of learning from the experience of early web-adopters

6.10 In addition to the above and in the context of applying the e-learning mode to marine engineering, the question is that of combining technical teaching with content organisation and delivery in an IT-enabled environment. Excessive emphasis on procedures and practices will not result in the targeted competence as envisaged by STCW 95. The onboard practice needs to be actively supported by structured instruction from ashore so as to enable the engineer to gain insights into practices in terms of concepts and processes.

6.11 The instructional design in respect of marine engineering should aim at:

1. *Reinforcement* of definitions and concepts
2. *Feel* of principles and relationships
3. Applications of principles and formulae to quantitative *problem-solving*
4. *Impact of process variables* on efficiency and safety; control objectives
5. Interrelationship between *controlled processes and related procedures*
6. Impact of *correct and incorrect procedures*
7. Rationale behind *emergency procedures*
8. Relationship between proper *maintenance* and safety, performance, reliability and operating cost

6.12 The model developed as a part of the present study gave an opportunity to put into practice, various concepts and principles relating to design of online course as applicable to in-service marine engineering education within the framework of STCW 95 guidelines. It also enabled development of simple tools and generic methodologies for:

a) recognising the pedagogical and technological choices in e-learning
b) correlating procedures and practices with processes through instruction
c) design and development of online course material
d) evaluation of pilot courses and the courseware available in the market
e) content organisation based on the interrelationship between theory, construction and operations and maintenance of marine equipment.

CHAPTER: 7

7. RECOMMENDATIONS

These recommendations envisage action from:

1) Ship owners and ship management companies
2) Maritime Education and Training institutions
3) Developers of courseware for maritime education and training
4) National Administrations
5) International maritime institutions such as WMU

7.1 This report anticipates and recommends two levels of integration insofar as development of a model for distance education support to seafarers in general and marine engineers in particular is concerned:

1) The first level is managerial and pertains to the learning environment onboard. It is recommended that ship owners and managers adopt a proactive approach in creating and sustaining a supportive training environment onboard their ships. This can be achieved by taking a strategic view of Human Resource Development and by collaborating with MET institutions, equipment manufacturers and courseware developers. National Administrations can encourage and guide such integration in the overall interest of sustaining the competitive edge of their seafarers in the global markets and to also meet, if not surpass, the global minimum standards of competence as required by STCW 95.
2) The second level of integration is technology-driven. E-learning has opened up new possibilities for integrating and enhancing various elements of IT-enabled content and delivery modes. It is recommended that MET institutions take a lead in exploring and tapping this new domain with the objective of providing cost-effective, in-service training support to seafarers. The options available to the MET institutions are:
   a) Develop low-cost packages themselves
   b) Tie-up with established developers and co-ordinate
   c) A combination of (a) and (b).

7.2 It is recommended that the e-learning courseware takes cognisance of the need for shifting the focus from procedures to processes, especially in the coverage of marine engineering topics. There is also a strong case for paying attention to content organisation to achieve a pedagogically significant correlation between theory and practice.

7.3 Since design and development of more elaborate simulations and Learning Management Systems are largely outside the domain of a number of smaller MET institutions, collaborative efforts with established developers are recommended as a long-term solution. It is recommended that all MET institutions may develop in-house expertise for understanding the e-learning aspects of courseware design and delivery from the pedagogic and user point of view to a degree that will enable them to make informed decisions while evaluating and procuring ready-made software.

7.4 It is recommended that MET institutions may consider regional co-operation and collaboration with other institutions of specialist and advanced learning including universities, as a viable option for cost-effective development of e-learning courseware and avoidance of duplication.

7.5 It is recommended that developers of maritime courseware may consider shifting of their developmental tasks to the developing countries so as to minimise costs; alternatively, it may so happen that developmental centres will emerge in the developing countries, which in course of time, will out-price the products from the developed countries. The problems of duplication and non-uniformity would still persist.

7.6 Reputed international maritime institutions such as WMU may consider development of 'standard', low-cost e-learning packages on the lines of IMO Model Courses to serve as a pedagogical and design guides for the MET institutions and courseware developers. This will be in line with the global minimum standards that STCW 95 is primarily concerned about.

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APPENDIX

DISTANCE EDUCATION SUPPORT:

MARINE ENGINEERING SERIES

INTRODUCTION: ALL ABOUT THIS COURSE

WELCOME ABOARD!

My name is U.R.P. Sudhakar, I am a marine engineer currently working in the Maritime Education and Training Services (METS) Division of National Ship Design and Research Centre (NSDRC), Visakhapatnam, India. I will be your tutor and contact person for this distance learning programme in marine engineering. Feel free to contact me on all matters relating to this course at:

unudurti_s@yahoo.com

I welcome you to this short course on centrifugal separators.

- **Who will find this course useful?**

This course is aimed at the marine engineer functioning at the support level and working towards the goal of becoming a certified, independent watch-keeping engineer. It will also be useful for the marine engineering cadets in their final year.

- **What is the aim of the course?**

The aim of this course is to impart knowledge and understanding of: the working principles, operation and maintenance of centrifugal separators.

- **What are the objectives of the course?**

On completion of this course, you will be able to:

1. Operate and maintain centrifugal separators in a safe and efficient manner
2. State their working principles,
3. Explain construction, operation maintenance procedures and
4. State the associated safety and environmental aspects.

- **How is the course structured?**

The course is organised in three sessions:

Session 1: Theory of Separation

Session 2: Construction of centrifugal separators

Session 3: Operation & Maintenance (including safety & environmental aspects)

- **How is the course formatted and delivered?**

It is formatted in three PowerPoint (MS Office 2000) files, one for each session. The material given in the PowerPoint presentation is elaborated in PDF files. I recommend that the PDF files may be printed and referred. They also contain background definitions, additional information and exercises. All the files will be delivered to you through e-mail. Exercise sheets and feedback form will be in MSWord files so that you can fill them. The PowerPoint and the PDF files are of 'read-only' type.

- **How long will the course take?**

Each one of the three session will not take more than an hour. In addition, you may need an hour for sending and receiving e-mails and attachments, printing, etc. So altogether, it is about six hours of work, spread over a week or two.

- **Why should one learn in such detail about centrifugal separators?**

1. Performance, efficiency and reliability of the Main Engine depend largely on fuel quality. Remember, today's engines operate within very narrow design parameters; but they are required to handle fuels of extremely poor quality.
2. High degree of reliability is required of them.
3. Separators are high-speed rotating machinery and call for specialist knowledge and skills for safe and efficient operation and maintenance.
4. Their running hours are very long, certainly longer than those of the Main Engine.
5. They do the dirty work for long hours; generate sludge & oily water that has to be disposed off in an acceptable way without polluting the marine environment.
6. Fuel accounts for nearly 50% of the operating cost.

- **What is the role of the participants?**

You are required to download the files that they receive, go through the PowerPoint presentations and the PDF files. At the end of each session, you will be required to answer a small objective type test containing ten questions. On completing the course (i.e., all the three sessions), you will have to fill a one-page feedback form and e-mail it.

- **Will the participants receive feedback on how they have done in the tests?**

Yes. You will receive an answer sheet with the right answers and a brief explanation. Your scores will not be revealed to or discussed with the other participants.

- **Can the participants discuss their progress with the others?**

Yes. In fact, you are encouraged to exchange your views and discuss your progress with fellow participants through group discussion on the web. A Yahoo discussion group called "full_ahead" has been opened for this purpose. You are also encouraged to discuss your progress with the tutor.

- **What do the participants need?**

You will need access to a PC (preferably Celeron or Pentium) with MS Office 2000 and Acrobat Reader (5.0 or above) loaded in it and periodic access to the Internet. You can download the PowerPoint and the PDF files on to floppies and work offline or on a different computer (without the need for the Internet). Test papers and feedback form will be in MSWord.

You will need to know how to download, copy files, send and receive e-mails and attachments. I suggest you maintain two separate folders; one for downloads and the other for the tests and form that you send out, after filling.

- **Are there any deadlines?**

Yes. It is important to have your answer sheets and the final feedback forms by 20th July, 2002.

- **Does the participant need to pay for the course? Can the course material be kept?**

It is absolutely free. You can keep the course material and use it in future.

- **Why is this service being offered?**

It is an experiment to study the usefulness of web-based distance learning support to marine engineers. Your feedback, comments and suggestions are therefore very important. You can help us in our attempt to improve distance education support to marine engineers onboard.

- **When will the course material be received?**

The material for the first session will be sent to you by 30th June. Send me your confirmation by e-mail that you received this file. Let me know if you had any difficulties in accessing or opening it. Most importantly, keep checking your e-mail at least twice a week!

[Disclaimer: This is not one of the courses that are being offered currently by National Ship Design and Research Centre (NSDRC) India or World Maritime University (WMU), Sweden. It is based on and limited to the individual efforts of U.R.P. Sudhakar, an employee of NSDRC and a student of WMU]

DISTANCE EDUCATION SUPPORT: MARINE ENGINEERING SERIES
COURSE ON CENTRIFUGAL SEPARATORS

SESSION 1: THEORY OF SEPARATION

OBJECTIVE OF THE SESSION

To develop a theoretical and conceptual framework so as to serve as a basis for understanding the construction, operation and maintenance of centrifugal separators.

Learning goals of this session:

At the end of this session, you will be able to:

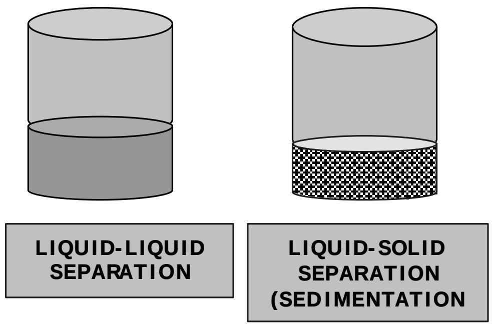
- Understand the processes of sedimentation and separation and the underlying laws.
- Appreciate the similarities and differences between separation occurring in gravity and centrifugal fields.
- Distinguish centrifugal force as a phenomenon resulting from inertia.

SEPARATION BY GRAVITY

Suppose that we take a mixture of two liquids of different densities or a liquid with solid particles and allow it to settle.

Over a period, the denser medium will settle at the bottom.

This separation has occurred because of gravitational force.



CONDITIONS FOR SEPARATION

For separation to occur (whether by gravity or by centrifugal force) in the mixture of two or more phases (i.e., liquids of different densities), FOUR conditions must be satisfied:

1. One of the phases must be continuous.
2. The other phases must be dispersed or held in suspension and must not be soluble in the continuous phase.
3. The phases must not have the same density.
4. The mixture must be held as far as possible, in a steady condition, i.e., without any agitation or turbulence.

The last condition is practically impossible to achieve on ships, since they are constantly in motion.

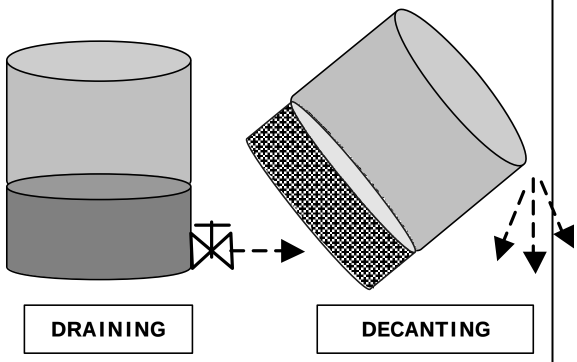
The chief disadvantage of separation by gravity is that it is a slow process and therefore not suitable for handling large quantities of mixture in relatively short durations.

SEPARATION BY GRAVITY

It is now possible to separate them – either by tilting the vessel (if it is small) or skimming the lighter liquid off from top. This is known as decanting.

In the Engine Room for example, settling tanks help to get rid of water from fuel oil. Water is drained out from the bottom of the tanks, since water is denser than oil.

As a general rule, oil always floats in water.



Stoke's Law

When a particle (solid or liquid) moves through a viscous medium under the influence of gravitational force, it will attain a constant velocity (V m/s) after a certain time. This is known as the sedimentation velocity and can be estimated from Stoke's Law:

$$V_g = \frac{d^2 (\rho - \rho') . g}{18 \mu}$$

Where

d = Particle diameter (m)

ρ = Particle density (kg/m^3)

ρ' = Density of the continuous phase (kg/m^3)

μ = Viscosity of the continuous phase (kg/m.s)

g = Acceleration due to gravity (9.81 m/sec^2)

Stoke's Law implies that:

- The larger the particle diameter, the greater will be the sedimentation rate.
- The greater the difference in density between the particle and the continuous phase, the greater will be the sedimentation rate.
- The lower the viscosity of the continuous phase, the greater will be sedimentation rate.

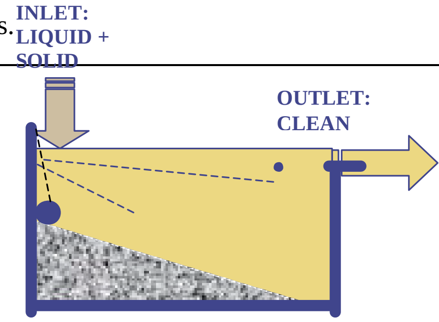
To increase the rate of sedimentation and therefore the throughput, can we increase the value of 'g'? That sounds incredible, but we will soon see that it is possible.

CONTINUOUS SEPARATION BY GRAVITY

Let us now look at continuous separation in which the tank content is not static but a flow is occurring. The figure shows an arrangement in which dirty oil is fed at one end of a tank and clean oil is decanted from the other. The solids settle at the bottom. Stoke's Law tells us that the sedimentation velocity depends upon the particle size. The bigger particles therefore attain higher sedimentation velocities and reach the bottom faster than the smaller ones.

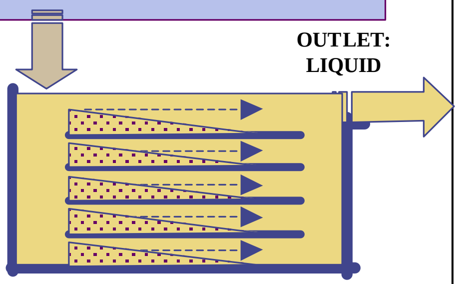
Taking longer to settle across the height of the tank, the smaller ones get deposited further and further away from the inlet.

If the particles are too small, their downward velocity may be so low that they reach the outlet and leave the tank along with the clean liquid.



Bigger particles settle near the inlet and the smaller ones get carried towards the outlet

While designing any purification (or filtering) system, the designers try to fix the limiting particle size.
Any particles bigger than the limiting size will not get through the system. In this figure, C represents the limiting size.
The corresponding velocity attained is called the limiting velocity or V_{limit}
The designer also wish to maximise the feed rate or throughput (m^3/sec)



It is possible to increase the settling area without increasing the tank size by adding a number of horizontal (baffle) plates

The time (t in sec) during which the liquid remains in the tank is obtained by dividing the volume (V in m^3) by throughput (Q in m^3/sec):

$$t = V/Q$$

$$= \frac{l\text{ (length)} \times b\text{ (breadth)} \times h\text{ (height)}}{Q}$$

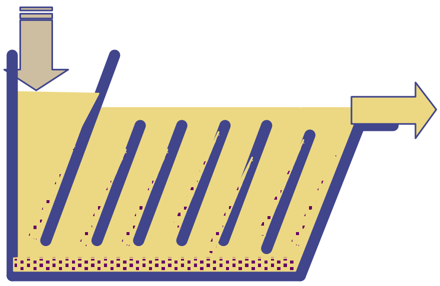
We know that $t = h/V_{limit}$

Therefore, $$\frac{l \times b \times h}{Q} = \frac{h}{V_{limit}}$$

or $$\frac{l \times b}{Q} = \frac{\text{Area (A)}}{Q} = \frac{1}{V_{limit}}$$

or $Q = A \times V_{limit}$

This means: throughput does not depend on the height (h) of the tank; It can be increased by increasing the settling area.

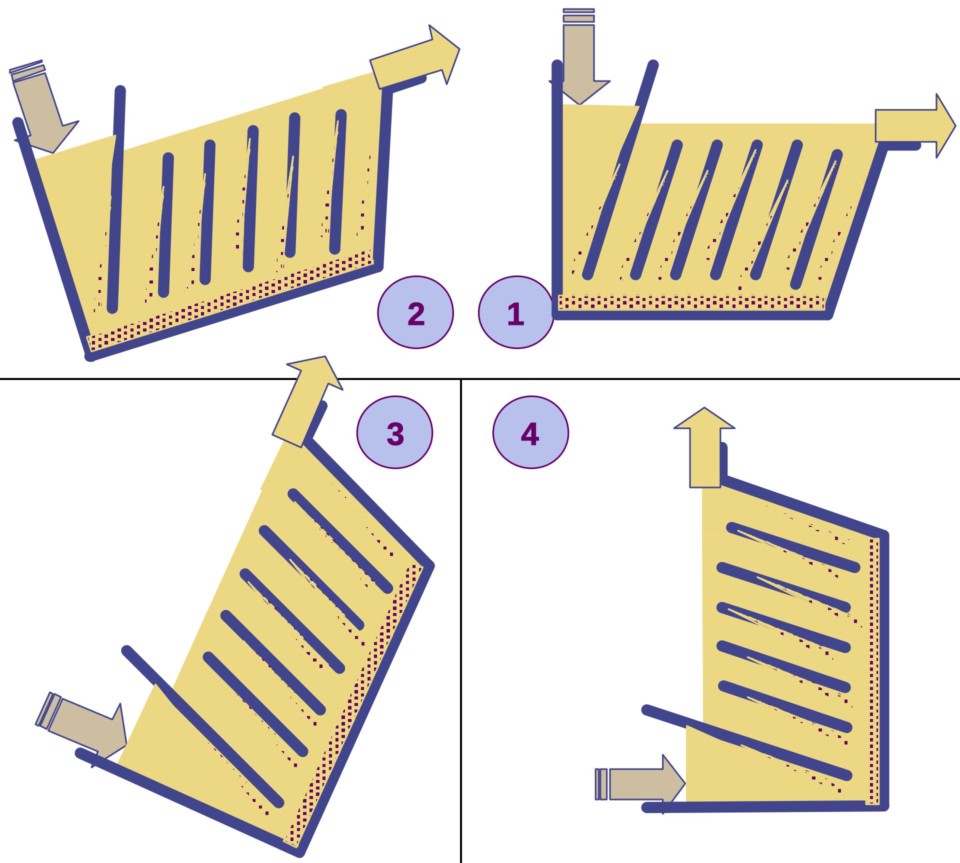


As sludge accumulates between the plates, it will obstruct the passage fuel oil.

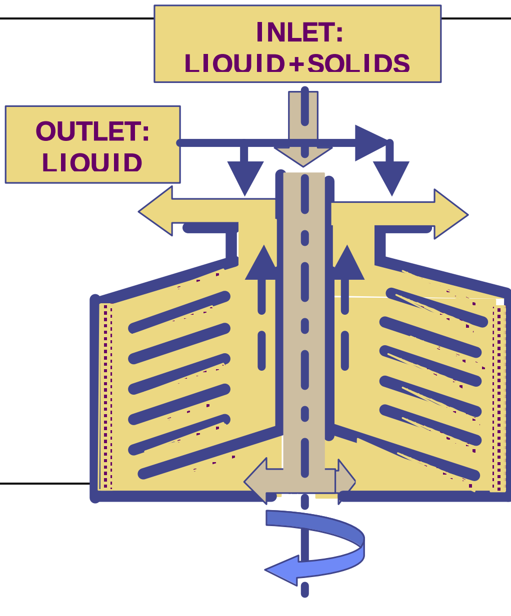
To avoid this problem, we may tilt the baffle plates.

FROM GRAVITY TO CENTRIFUGAL SEPARATION

LET US TILT THE TANK ARRANGEMENT…..



….AND ROTATE IT….. WE NOW HAVE A CENTRIFUGAL SEPARATOR….



CENTRIFUGAL FORCE	Before we look at the details of construction, let us briefly recall our understanding of centrifugal force…..

According to Newton's First Law of Motion: *"Every body continues to be in a state of rest or of uniform motion unless acted upon by an external force*". Such persistence is known as inertia.

The force that you feel in a fast-moving vehicle while negotiating a curve is not due to something actually pushing you in that direction, but by your body's inertia trying to keep you moving in a straight line.

At a rotational speed of ? radians/sec and at a radius of r meters, the velocity will be ? r m/sec.

Here, the change in velocity is occurring because of the change in direction rather than magnitude; in one second, the body would have travelled ? radians

Acceleration = Change in velocity/sec

= Arc length BC

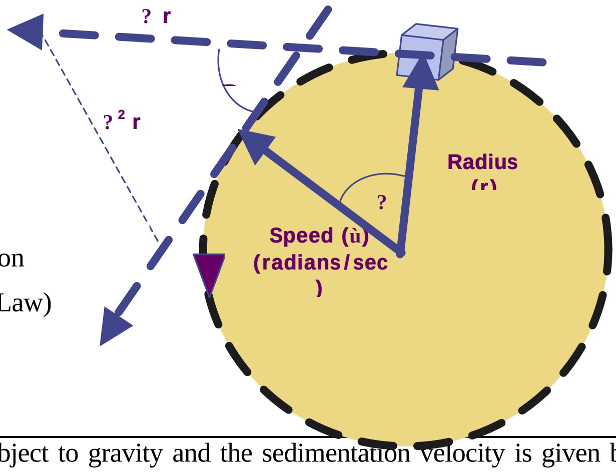
= Radius (? r) x angle(?)

= $?^2$ r m/sec^2

Centrifugal Force (N) = Mass x Acceleration

(Newton's Second Law)

= m $?^2$ r N



In the settling tanks, a solid particle is subject to gravity and the sedimentation velocity is given by Stoke's Law:

$$V_g = \frac{d^2 (r - r') \cdot g}{18 m}$$

The same particle, when subject to centrifugal force in a separator, would attain velocity V where

$$V = \frac{d^2 (r - r') \cdot ?^2 r}{18 m}$$

V/V_g = ($?^2$ r)/g = 'g' factor

The 'g' factor indicates how many times greater the sedimentation rate would be in a centrifugal field when compared to the gravity field.

EXAMPLE

In a centrifugal separator rotating at 1500 RPM at 0.5 m effective radius, the g-factor would be:

[(2? 1500/60)^2 x 0.5]]/9.8 = 1250 (approx.) times the gravitational force.

The sedimentation velocity reached in the centrifugal field will therefore be around 1250 times the value in gravity field.

SUMMARY

Before moving on to the next section on construction and operation of separators, let us summarise what we have learnt in this session:

- Separation by gravity is of limited use onboard since throughput cannot be raised and ships are not steady.
- Stoke's Law implies that higher separation and sedimentation rates could be achieved if the particle diameter is large, the difference in densities is significant and the viscosity of the continuous phase is low.
- Sedimentation rates do not depend on the height of the tank but increase if the settlement area is increased.
- A centrifugal separator may be visualised as a rotating settlement tank with a number of baffle plates.
- Centrifugal force is experienced as a result of inertia.
- For a given mass, the centrifugal force varies directly as the square of the angular velocity and the radius.

ADDITIONAL INFORMATION

Viscosity: Absolute & Kinematic

In layman's terms a highly viscous liquid is said to be "thick" and less viscous liquids are referred to as "thin". In more scientific terms, viscosity is a measure of the internal resistance of a fluid. The absolute viscosity of an oil is defined as the resistance to flow and shear under the forces of internal friction.

This internal friction is caused by the resistance of oil molecules moving relative to each other. The larger the molecules, the higher the internal resistance and consequently the higher the absolute viscosity. The absolute viscosity of an oil is usually measured using a Brookfield or Rotary Viscometer.

Kinematic viscosity on the other hand, is a measure of an oils resistance to flow and shear under the forces of gravity. Again, the larger the molecules, the greater resistance, the higher the kinematic viscosity. Kinematic viscosity is usually measured using a Capillary Tube Viscometer of standard dimensions and is the method most commonly used by oil analysis labs to determine an oils viscosity.

Representative units for viscosity are kg/(m.sec) (also known as poise designated by P). The centipoise (cP), one hundredth of a poise, is also a convenient unit, since the viscosity of water at room temperature is approximately 1 centipoise.

Viscosity of liquids in general, decreases with increasing temperature.

Laboratory measurements of viscosity normally use the force of gravity to produce flow through a capillary tube (viscometer) at a controlled temperature. This measurement is called kinematic viscosity. The unit of kinematic viscosity is the **stoke**, expressed in square centimeters per second. The more customary unit is the **centistoke** (cSt) — one one-hundredth of a stoke. Kinematic viscosity can be related to absolute viscosity by the equation:

cSt = cp ÷ fluid density

SUGGESTED READING

Reed's Applied Mechanics: Chapter 5: Centripetal Acceleration

DISTANCE EDUCAION SUPPORT:
MARINE ENGINEERING SERIES
COURSE ON CENTRIFUGAL SEPARATORS

SESSION 2: CONSTRUCTION OF CENTRIFUGAL SEPARATORS

Objective of this session

To explain the construction of centrifugal separators

Learning goals

At the end of this session, you will be able to:

- Identify the key parts of centrifugal separators
- Explain the function of these parts
- Describe the action of 'self-cleaning'
- Appreciate the function of the gravity disc
- Differentiate between a clarifier & a purifier

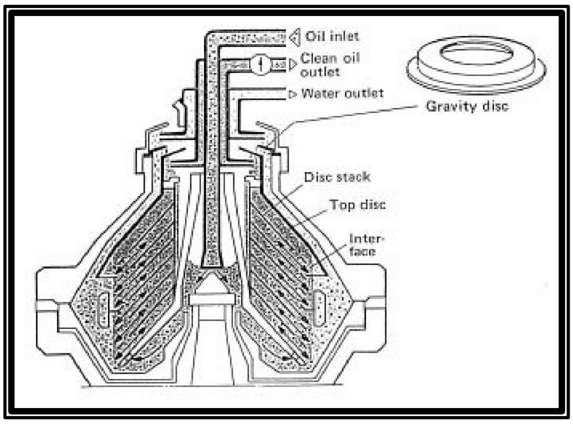
Construction of the separator is characterised by the use of accurately machined stainless steel parts and features that allow assembly in one particular way ensure:

- Dynamically balanced assembly of rotating parts
- Ease of cleaning
- Less chances of wrong assembly

SECTION THROUGH BOWL ASSEMBLY

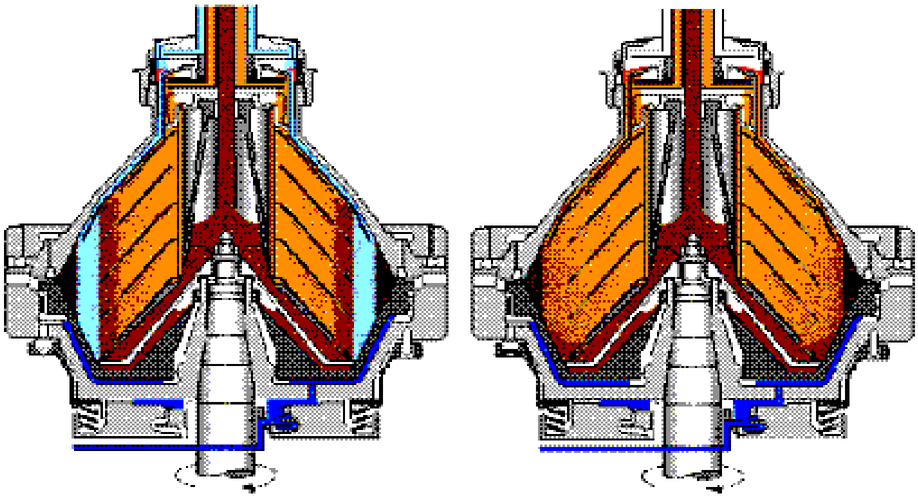
(Self-cleaning type Purifier)

The operating water under the sliding bowl bottom (shown in dark blue here) keeps it pressed against the bowl hood. Sealing is by means of a teflon ring located in a groove on the underside of the hood.
When the operating water pressure is released briefly, the sliding bowl slides down to release the sludge from the periphery through the port provided in the bowl body.
The 'de-sludging' action can be carried out manually or automatically – at periodic intervals (usually once every four hours)

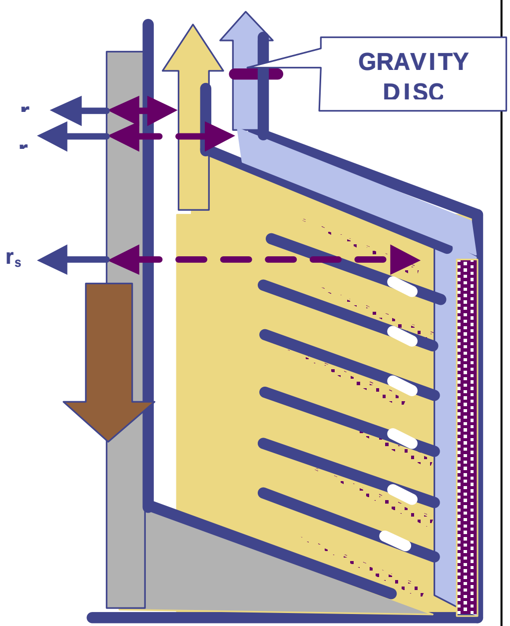


TYPES OF CENTRIFUGAL SEPARATORS

1. **PURFIER:** Simultaneous Liqud-Liquid and Liquid-Solid Separation
2. **CLARIFIER:** Liquid-Solid Separation



- Solids (sludge) and the heavier phase (water) are collected at the periphery of the rotating bowl and lighter phase (oil) stays closer to the centreline.
- Note the holes on the discs near the interface. These holes allow the supply of dirty oil into the disc stack without disturbing either of the separated phases.
- Each liquid leaves the separator though its own outlet; the accumulated sludge is removed periodically either by cleaning or by 'de-sludging'.
- The liquid-liquid interface (r_S) has to be as far away as possible from the centreline. This is to provide maximum possible volume for the liquid to be purified.
- If the interface goes beyond the edge of the top disc however, oil will be lost with water (this is known as 'breaking of the seal).
- If r_S is too small and the interface too close to the centreline, purification will not be efficient.
- Water should not enter the disc stack but the interface should remain inside the top disc



SELECTING THE GRAVITY DISC

Consider the arrangement to be a U-tube with two different liquids so that: $?_l$ x h_l = $?_w$ x h_w, where

$?_l$ = Specific Gr. Of the lighter phase h_l = Height of column of the lighter phase

$?_w$ = Specific Gr. Of the heavier phase (or water) h_w = Height of column of the heavier phase (water)

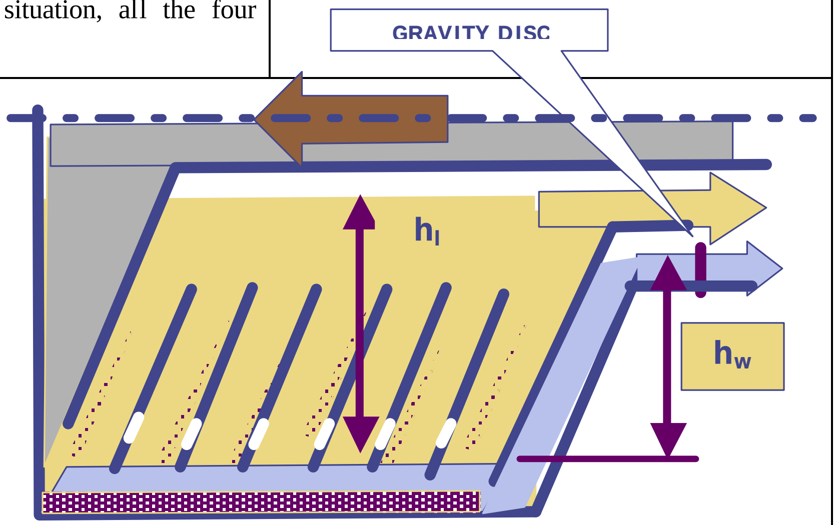
In a given equilibrium situation, all the four values above are fixed.

We can see that the inner edge of the gravity disc is acting like the top of a dam.

Any lowering of the dam will cause the interface to move further away from the centreline to maintain h_w constant. It is therefore appropriate to use the gravity disc of the biggest possible size in a given situation.

The objective is to maximise the volume of the lighter phase in the disc stack.

At the same time, the risk of losing the seal must be avoided.



SUMMARY

There are two operating modes in which a centrifugal separator can be used:

PURIFIER : Simultaneous liquid-liquid <u>and</u> liquid-solid separation

CLARIFIER : Liquid-solid separation

In a purifier, correct choice of the gravity disc is important so as to ensure that the:

Liquid-liquid interface is as far away as possible from the centreline of rotation;

Lighter phase (the liquid to be purified and used) is provided with as much volume in the bowl as practically possible; and at the same time,

The liquid seal is not broken.

It is appropriate to use the gravity disc of the biggest possible size in a given situation of purification.

DISTANCE EDUCATION SUPPORT:
MARINE ENGINEERING SERIES
COURSE ON CENTRIFUGAL SEPARATORS
SESSION 3: OPERATION & MAITENANCE OF CENTRIFUGAL SEPARATORS

Objective:

To understand and list the actions required of the engineer-on-watch in respect of centrifugal separators and their application to treatment of Heavy Fuel Oil. These actions will ensure:

- Safe and efficient operation
- Proper maintenance
- Prevention of marine pollution

Learning goals:

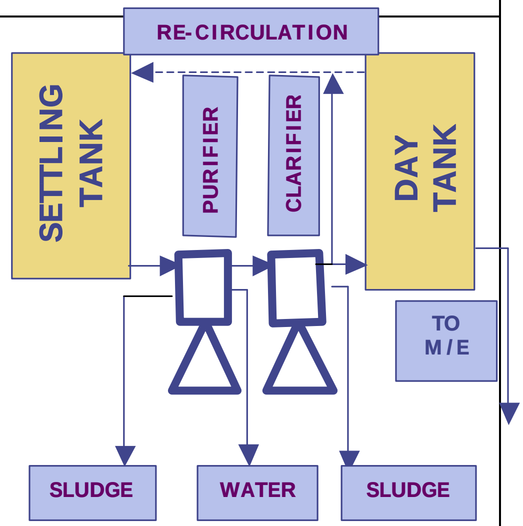
At the end of this session, you will be able to:

- Acquire knowledge & understanding of efficient and safe operation of centrifugal separators.
- Recognise the key areas that need attention during maintenance
- Identify measures for prevention of marine pollution arising from operating separators.

PURIFIER & CLARIFIER IN SERIES

The recommended combination for application of centrifugal separators to treatment of HFO is a series arrangement in which:

- HFO is first passed through a purifier. Water and some amount of sludge are removed in this stage.
- HFO is then passed through a clarifier for further refinement and removal of the remaining sludge.
- Operating in series improves the results of separation significantly.



The operating objective of efficient purifier operation:

Keep the interface just outside the disc stack but within the top disc.

Consider that the gravity disc has been selected correctly and the purifier is running satisfactorily.

Recall the equilibrium condition

$$ñ_l \times h_l = ñ_w \times h_w$$

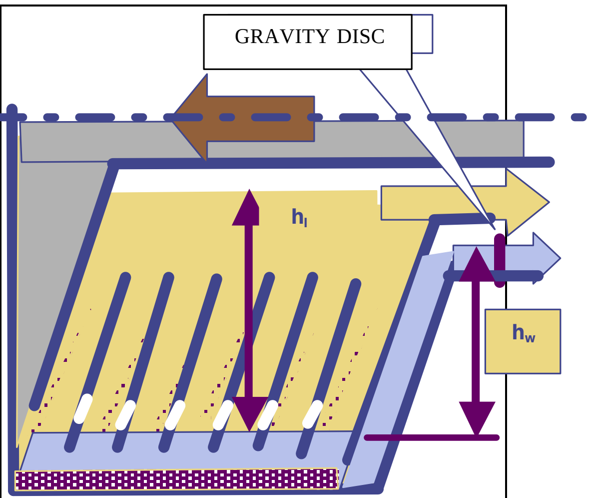
Change in inlet oil temperature can change this situation.

The specific gravities of the liquid phases vary inversely with the temperature.

As a result, the position of the interface may shift.

Either the seal may break or the purifier will operate inefficiently.

Decrease in feed temperature can cause the viscosity to increase, which in turn, will reduce separation velocity as governed by Stoke' Law



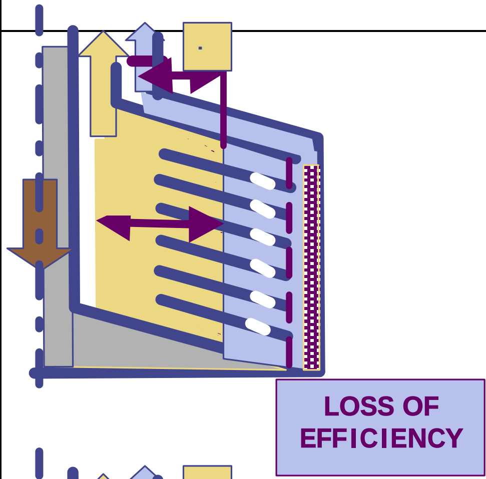
Decrease in SG of oil → **Interface moves in towards the centreline**

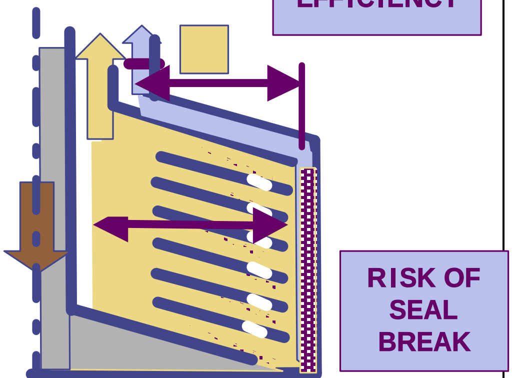
Increase in SG of oil → **Interface moves out and the seal may break**

The impact of variation in feed temperature can be summarised as follows:

Parameter	Change	Result
Temperature	Increase	
Density	Decrease	Interface
Viscosity	Decrease	moves in
Flow (t/h)	Decrease	

Parameter	Change	Result
Temperature	Decrease	
Density	Increase	Interface
Viscosity	Increase	moves out
Flow (t/h)	Increase	





To ensure efficient operation:

Step 1: Use gravity disc of maximum possible size

Step 2: Maintain feed temperature

If bunker characteristics change, redo steps 1 & 2

SAFE PRACTICES
Use of special tools, correct dismantling, re-assembly and tightening are very important since separators are high-speed rotating equipment and any dynamic imbalance can result in serious damage and injury. No lose parts/tools must be left behind. Operational/maintenance status of each separator must be clearly indicated to the next watch keeper while handing over. Always follow the manufacturer's instructions for starting, stopping operation and maintenance.
MAINTENANCE
Incorrect operation can result in the need for additional maintenance and breakdowns. Maintenance on separators consists mainly of: ➢ Cleaning of disc stacks ➢ Changing of sealing rings ➢ Clearing of scale from the passages for sealing & operating water
SUMMARY
For most efficient separation, let the dirty oil pass through a purifier first and then through a clarifier. Select the largest possible gravity disc in the purifier for a particular fuel and feed temperature Maintain the temperature to ensure steady operating conditions and best utilisation of the disc stack without at the same time, risking breaking of the seal. Since separators are high-speed rotating equipment and any dynamic imbalance can result in serious damage and injury, exercise care during dismantling and re-assembly. Status of each separator must be clearly indicated at the time of change of watch in the Engine Room. Follow manufacturer's instructions. Considerable amounts of sludge and oily water are generated by the operation of centrifugal separators. These are to be disposed off in accordance with the MARPOL Convention.
Additional information:
This brings us to the end of this course on centrifugal separators. Description and operation of ALCAP (Alfa Laval Clarifier And Purifier) will be taken up in a separate course.