Chapter 12
Smart Shipping Needs Smart Maritime Education and Training

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12.1 Introduction

The rapid development of digital technologies in recent years and the exponential growth of computing power and storage capacity of “wise machines” lead inevitably to the increasingly important role of artificial intelligence (AI) in many fields of activity, including maritime transport [1, 2]. These developments, combined with growing global challenges, give us reason to believe that, if not in the coming years, then in the coming decades, we definitely will face major changes in the world in general and in maritime affairs in particular. They, among other things, will force us to abandon the beliefs and paradigms that have so far seemed to be “waterproof.”

Before discussing in a practical way the problem posed in the title of this paper, it is essential to ask some to a certain extent philosophical questions, which inevitably arise when analyzing this topic and which cause a slight dissonance in the author. There may not be (or even cannot be found at all) good answers to these questions, especially within the scope of single paper, but defining these questions and “bringing them into play” seems important to the author of the paper.

The first question is what we mean by talking about something or someone “smart” (smart person, smart behavior, smart economic, smart shipping, or even smart education). It is clear that the answers to the question about the “smartness” of the listed objects and subjects, even if they could be found, would differ significantly from each other. The author of this paper does not attempt and even probably is not able to give an exhaustive definition of “smart” for all these objects and subjects (and possible many others). However, the author would like to clarify what he
believes could be the “smartness” of future shipping and maritime education that directly related to it, at least in view of some important aspects.

The title of the paper explicitly suggests that the need (or at least one of needs) to make maritime education “smarter” lies in the fact that shipping is becoming, or at least it is expected to become, “smart,” so defining “smart shipping” in the context of this paper is important. Only by clarifying what does it mean will it be possible to understand what education is needed in this context and what the “smartness” of that education should be.

In general, the use of the word pair “smart shipping” refers today primarily to the taking into use of the latest technological solutions, i.e., digitalized and algorithmic shipping, mainly the deployment of so-called intelligent ships at sea. The term “intelligent ship” implies that all or the vast majority of decisions for such type of ship are made not by humans (who are probably not enough intelligent) but by AI. Presumably, the role of seafarers will be taken over by artificial intelligence, either in full or in part. Consequently, if digital shipping is a priori smart, it inadvertently leads to the conclusion that the lack of wisdom or even stupidity is the prerogative of the human, and the lower the share of human participation or intervention, the smarter shipping is.

According to this, there would be nothing wrong with shipping itself as an essential component of the global supply chain. Shipping or, more broadly, maritime transport perfectly serves today the needs of stakeholders and economic system in whole that built on the postulates of infinite growth and making a profit. In other words, it is assumed that making shipping smarter is not a question of changing shipping itself, i.e., its priorities and goal settings, but only a question of improving the form of performance. The more digitalization and the less human intervention, the more wisdom and less stupidity in the system will be. In principle, the author has nothing against such an approach, although this position is quite controversial, but the author would like to approach it from a little different angle.

It is supposed that smart or otherwise digital shipping will serve the system better, enabling shipowners and other beneficiaries to make greater profits. Yes, of course, it will serve better, but the question is, is the current economic system and the way humanity lives on Earth in general smart? If smart solutions serve not a very smartly designed system and faulty goals, can we call those solutions “smart”?

In the opinion of the author of this paper, we cannot. Not only and not so much reducing the costs of beneficiaries and helping them to win in the competition, thanks to digital solutions, should be the sign of wisdom and the main purpose of attainment. Humankind developed so far that all the fields of activity, industries, paradigms, and theories need a radical revision, finding out fundamentally new and nonstandard solutions. Shipping, like virtually all other human activities, must become smarter at a fundamentally new, meaningful higher level, and for achieving of this goal, the education, including maritime education, needs to be revised.

In the author’s opinion, now is the right (if not the last) time to review the basic (first of all economic and social) theories and postulates and give ourselves honest answers about what is happening and what is smart and what is not. Perhaps the shipping that, thanks to digital solutions, will be able to transport more and more
goods with the same or even lower costs, make more profit, and be more competitive on the market cannot be called “smart” for that reasons only. It seems that the smart is shipping that allows, thanks to digital solutions, to find more optimal ways of reducing the negative impact on the environment, to make the consumer society more sensible, and to reduce ultimately the risk of humankind self-destruction. Such an approach should also significantly change the question of defining smart maritime education.

The second question is who is the target group for “smart” maritime education? The answer is obvious, the reader can say. Those who study in the education institutions are the target group. The answer is correct, but it seems that those who study become predominantly maritime transport employees, in other words more or less mindless performers, not decision-makers. As a rule, those who make a profit and make decisions in maritime do not study something that is not directly necessary for their businesses and other similar activities. It can be said that in maritime affairs (as in many other areas), the principle of stratification may be observed, according to which at least three parallel “worlds” coexist: stakeholders and other beneficiaries or “moneymakers,” politicians and other officials or “decision-makers,” and employees on different levels or “job makers.”

The latter, who are definitely the target group for (smart) maritime education, must serve the first and partly the second group. Thus, they have little opportunity to make a significant impact on the solving of real large-scale problems using advantage of their smart education; the primary achievement for them is to be able to earn a living for themselves and their families. Science that closely intertwined with and based on education is in the same position. Science needs money to function, and more and more money is needed today to do good science. As well known, who pays, that orders music.

The actors of first and second groups could benefit from an eye-opening and making them smarter professional maritime education, and even more universal education; thanks to that, they would not make moneymaking decisions without considering the issues of expediency and sustainability. As rule, they are usually not interested in such kind of education. They probably do not have time to make such a mess because they are busy on moneymaking 24/7. Of course, they may learn something: business administration, financial management, etc., but there is little point in contributing to the solution of problems of humankind.

Thus, the author realizes that no matter how much he would like the maritime education (and education in general) to become smarter and thus contribute to the improvement of the world, it seems to be more a dream than reality. Many educated people may understand what is going on, but if the few ones who can really make decisions and change things are not among them, their understanding can change nothing.
12.2 Development Trends in Education

A Brief Historical Overview

One of the fundamental principles of how the world works is that major developments take place in the form of a spiral [3]. There is a well-known saying that “everything new is a well-forgotten old one.” This is true, but since everything is constantly in the processes of changing, the new never is the same as old, but this is old transformed into new conditions, at a new level of development, so the processes may be shaped like a spiral. This also applies to education, both in the most general sense and in terms of different areas of education.

If we look back in time, we see that humanity’s capacity has grown incredibly over the last 500 years, both in scale and speed, and in most areas, this growth has been exponential, and it is continuing. Suffice it to say that during last ca. 500 years, humanity has grown about 14 times, production 240 times, and energy consumption 115 times [4, p. 322].

This ever-accelerating process started with the so-called scientific revolution, which began the era of modern times about 500 years ago. A key feature of the past years is that humanity has invested more and more resources in research and science during this time, through which it has acquired unprecedented new capabilities and gained more and more new resources as a result. This change can be named “revolution,” because before that, both governments and wealthy people allocated some money for science and education, but primarily with a view to maintaining existing capabilities, not acquiring new ones [4]. Before scientific revolution, the high-quality education was the privilege of rich and talented individuals, and the ways and means of acquiring it were their own concern or, more precisely, were determined primarily by their status in society.

While before era of modern times, education was the privilege of the individuals, the scientific revolution led to the emergence of educational institutions, i.e., universities (which became also research institutions), but the education received there was not initially intended for the masses. The purpose of that was not only, or even not so much, the acquisition of knowledge for a specific profession, but rather it was the acquisition of universal knowledge. As a rule, what was learned at universities covered a wide spectrum; university graduates were the people who were interested in many fields of science and the connections between them, and some of them were the ones who carried forward science in the broadest sense of the word and made major discoveries and inventions during the centuries.

Although a general division between the humanities and the real sciences was already emerging at the universities, the line between them was initially blurred, and it was more common to acquire a complete picture of the world rather than a narrow discipline. In modern terms, people with such an education could be named as “generalist” (that did not express contempt yet at that time); it would be preferable to call them “universalists” or even more precisely “holists.”
However, they should be honored, because thanks to talented individuals’ curiosity and thirst for knowledge of some of them, they were finally behind a breakthrough and an ever-accelerating triumph of science.

Taking into use a water and steam power *ca* 260 years ago to mechanize production and introduction of electricity and taking into use fossil fuels *ca* 150 years ago were named accordingly the first and the second industrial revolutions. The third industrial revolution was the vigorous development of electronics and automation, and computer sciences as well, which came to the aid of mass production automation about 50 years ago [5]. Today we are talking about the fourth industrial revolution (Industry 4.0), which is actually a continuation of the third one at a new qualitative level; the second name of it is the digital revolution. From the point of view of education, the key word in all these periods is “mass”; that means first at all mass production, the other side of which is mass consumption. As education began to serve more and more the industry (in the broadest sense of this word) during the industrial revolutions, we can speak of education becoming mass education from the second half of the eighteenth century.

**Specialist vs. Generalist**

The key word for mass production serving education has been “specialization.” Ideally, owner of the production unit wants to see people in his production facilities who can perfectly perform a single operation or set of certain operations. Even towards creative people (e.g., engineering staff, product developers, managers, etc.), the word “specialist” has a positive meaning; a specialist is one who knows everything or almost everything about one specific thing or area and is able to develop them in the most optimal way.

The opposite of the “specialist” is naturally the “generalist”, who, on the contrary, acquired a little negative background during the industrial revolutions’ times. The generalist may know in total no less than the specialist may; in fact, generalist knows more, but he or she knows as rule only partially about any particular things, and there is nothing he knows all about (otherwise he would no longer be named as a generalist). Much of knowledge of generalist cannot be directly useful in mass production; at the same time, effective visionaries and “idea generators” are often generalists who have a broad horizon and can see the “big picture” or, otherwise, we would name them “universalists.”

Today’s formal education (universities, vocational schools) has reached the peak of maximum in specialization. International Standard Classification of Occupations (ISCO-88) contains thousands of occupations divided into nine major groups [6]. Each university has hundreds of curricula, many of which can have in turn several specializations; thousands of several specialties are studied in vocational training institutions as well. A graduate in one specialty is usually more or less ignorant in all other specialties. This is also understandable because the high technical and technological level in most areas means that in order to become a specialist of
excellence, one has to dedicate nearly half of active life to acquiring this specialty, i.e., learn and acquire knowledge and practical skills for decades. The situation is similar in science: the more and more narrowing specialization of research topics leads to the fact that professional articles in one field are poorly understood or not understood at all by researchers in other fields, not to mention so-called ordinary people.

One may ask, what is wrong with that? Every person learns one thing as clearly as possible and becomes a top specialist in it. Everyone is highly valued in his or her workplace and does not fear to become a miserable loser in the competition. Top specialists do good job; their products and services are of high quality. Top-level researchers with narrow specialization are able to effectively develop their field of research and eventually achieve success and, if they are doing well and lucky, become laureates of Lifetime Achievement Award and even, why not, Nobel Prize laureates. Everything seems to be fine.

However, such narrow professionals, be they in industries or in sciences, have one major drawback: their excessing commitment to one discipline does not leave them much room to see the big picture. Sometimes they are unable (often unwilling) to relate their actions to potential consequences of them, which can have a much wider and more negative impact than they might think. There is one good saying about it: “No seeing the forest behind the trees.” The development of human civilization has reached a stage where all the people have to think about what they are doing and where their actions will eventually lead. The visionaries or universalists with a wide horizon and nontrivial thinking are again may be not less, but even more important, than specialists for the survival of humankind. Moving along the spiral, we are back, but on a new level.

12.3 Smart Maritime Education

New “Old” Priorities

In publication [7] the author examines, inter alia, maritime safety issues in the coming era of smart shipping. Ensuring the safety of human life at sea has always been one of the main priorities of shipping; the second priority is the preservation of property, first with regard to ships and goods. The protection of the marine environment may be mentioned as a third priority; unfortunately, until a few decades ago, this priority was clearly below the first two in terms of importance.

These priorities will certainly not become less important even if full-autonomous, semi-autonomous, and remote-controlled vessels become more and more powerful in occupying their rightful niches in shipping. At the same time, the relationship and interaction between these priorities can change significantly, and it is vital that decision-makers and main actors in maritime understand this in a timely manner.
and reshape their personal and corporate goals and attitudes according to changing circumstances.

Primarily it concerns the safety of human life. If the ship is autonomous or remote-controlled, there shall be no persons on board during the voyage and, in the event of an accident, no one will be endangered immediately, at least until the ship in distress endangers other ships, other facilities, and persons on them. At the same time, for people who come to the rescue of an unmanned ship in distress and the goods on board, there will still be a danger. However, important difference is that at least there is no difficult choice as whether and how much to risk the lives of some people in order to save lives of other people. Rather, it is a choice of whether or not to risk human lives to save property. This second option seems much easier.

Pollution of the marine environment with oil and oil products, plastics, etc. leads initially indirectly and locally but later ultimately directly and globally (through drastic changes in the living environment) to endanger people’s lives and health. It is therefore important to be aware of the possible consequences of one or another activity, not only in the short term but also in view of the far-reaching results. It is hard to believe that an AI programmed at any price to protect the property “entrusted” to it will be able to make the right strategic decisions of such kind. These decisions remain the prerogative of the human beings, and the smarter the education they receive, the smarter decisions they make.

One of the important problems of people who have studied narrow specialized professions is that they often are not able to think of themselves as an integral part of big system (society, humanity). They do not realize that everything they do and all the decisions they make not only affect their own life and well-being but in one way or another extend to other people and further to the community, ecological system, and thus all humankind. Many know the famous theory about the “butterfly effect” [8], but few are able to identify themselves with this effect.

**The Growing Importance of Diversity**

When going to work on any conventional ship, a ship’s officer today must know and be able to do mainly the same things; the differences due to the type, size, etc. of the ship are not very large. Hence, the level of standardization and unification of modern legislation governing maritime education, first the STCW 78 Convention, is high [9].

One of the features of the near future is that both in life as a whole and in its various fields, more or less applicable several solutions are possible, the choice between which is not always as unambiguous as one might think. In standardized and unified (maritime) education, it applies usually “the only one right solution” principle, which means that there is always one right course of action in every possible situation, which must be clarified during theoretical and practical studies and even better played through on the simulator; in any such situation, this solution must be implemented without much thought. In general, this principle is the basis of an unmanned
ship control algorithms. However, already today, and even more so in the future, there will be the implementation of the right solutions in shipping an increasingly multivariable activity. A choosing between these variables is not an easy task; the author dares to say that in some cases the AI may not be able to perform this task perfectly. It still has to be done by the captain (in the case of an unmanned ship, the shore operator).

As one such example, we can imagine a situation where we choose between a bad choice and an even worse one which must be done: either collide with another ship or steer your ship to the ground to avoid a collision. All solutions are bad, but less bad one have to be chosen, as a rule in the time scarcity conditions. An AI that is programmed to protect anyway the shipowner’s interests may choose to steer own ship bow to the center of the other ship’s side, which is likely to ensure relatively little damage or at least a floating position for the ramming ship. For another ship, this would mean much more serious consequences, with high probability a ship-wreck. Moreover, if this other ship is a fully loaded tanker, severe consequences for the marine environment are likely to be expected. Can for specific response programmed AI consider all this and, more importantly, make a decision, which contradicts his algorithm? Probably not. However, a captain or shore operator must be able to do it, and his or her fundamental knowledge, attitudes, and, most importantly, personal characteristics play a crucial role in this.

If we talk about the increasing diversification of the knowledge and skills needed at sea, there will be more different options in the near future, than there are now. When acquiring maritime education, branching points should already emerge during the studies; from those points, students go to one degree or another in different ways by acquiring their future specialty. Ultimately, those who go on board conventional vessels and those who will operate remote-controlled vessels from shore-based control centers must have not quite the same knowledge and skills.

These two are opposite variants: one is for those whose entire working life is spent, as it is today, on board the ship, and the other is for those who perform their duties in full on shore (yet we must call both those seafarers). However, there may be a considerable number of intermediate variants between them, for example, those who are employed in regiments serving fully autonomous vessels and have to deal promptly with any kind of problems that may arise with such kind of vessels at sea.

The author of this article believes that developments in the ships’ digitalization and becoming “more intelligent” will not be sudden and rapid from one marginal case to another; so-called semi-autonomous solutions are more likely to emerge in the coming years, e.g., the 3M and MP variants described in the author’s publications [10, 11]. Even this will also take a long time, perhaps decades, to reach the mass application of such solutions, not to mention fully autonomous ones.

Initially, several variants will be made for gradually increasing the role of digital solutions and AI in the management and operation of manned ships. More than one intermediate variant will emerge, which differ in the degree of AI interference in the control and operation of the ship. Computers will take over more and more ship operation and management functions; they will not only reduce the need for human intervention, but also the functions of people on ships will change all the time. This
requires increasing of the ability of crewmembers to constantly learn and retrain and, among other things, to work effectively together with AI.

This means that the qualifications and knowledge of future seafarers must also evolve, depending on the degree of automation and digitalization of vessels, on which they are to be employed. The knowledge of these people must be universal on the one hand, because they must be able to cope with new types, including unexpected situations, and on the other hand, it must be specific, i.e., they must be experts in the intelligent systems that the ship probably will be.

Supposedly, operators of remote-controlled vessels are unlikely required (and probably they cannot) to be top-level IT professionals, but they should have IT education on level that gives them certain advantages. First, it would allow them to understand what is happening in the first moments of a cyberattack or other major failures in order to implement the most basic preventive measures in order to prevent or at least slow down as far as possible the subsequent negative developments; the speed of response can be crucial here. Second, they must be able to successfully communicate and collaborate with relevant IT and AI professionals, both in routine and emergency situations.

The qualifications of the developers of “smart shipping” algorithms are also important. It is vital that the algorithms are not only based on the results of statistical processing of Big Data but also take into account the specificities of the field, including possible effects and consequences. The algorithmic developers should either be maritime experts to one degree or another or receive qualified assistance from experts with maritime training and maritime experience as well as IT expertise.

**Key Concepts for Future Maritime Education**

The focus of maritime education must shift from what is taught to how. In his previous publications [7, 11], the author discussed the essential professional and human qualities of the people working in shipping today and especially in the future and described them in terms of diversity, personal achievements, social values, and preparedness for future challenges. Here, the author would like to add a sense of responsibility and thinking ability. Highly standardized and formalized maritime education must become education that develops more creativity and independent thinking.

In addition to the need for diversity in maritime education, as described in Sect. 12.3.2, the author highlights three key requirements described in his publication [11] that he believes should characterize the changes that will need to take place in the near future in the education of seafarers. The first is to make specialty subjects and the whole learning process more complex. The second is closer and more meaningful cooperation both between teachers and between teachers and students; it is clear that without it, the first goal cannot be achieved at all. Third is flexibility, i.e., quick response to changes in professional life and life in general and bringing education in line with them.
In order not to repeat himself, the author will not explain these key concepts in detail; those interested can be acquainted with them in the publications [7, 11]. However, the author would like to describe briefly some of the changes in the learning process of his home institution that he has undertaken to implement his concepts.

Case study  As the author of this paper is the Head of the master’s study program “Maritime Studies” in Estonian Maritime Academy and one of the lecturers of this curriculum, he has a good opportunity to launch so to say a pilot project in cooperation with two other lecturers of the program. The aim is to introduce in teaching process a new complex course (hereinafter referred to as CC) based on the three courses of special studies currently being separate in the curriculum, applying the principles described in general terms before. Due to the limited volume of the paper, it is not possible to describe this project in detail here; the author only outlines its essence and main features.

The CC is formed on the basis of the following three courses: Maritime Cluster and Shipping Economies, Port Operation and Basis of Management, and Maritime Law. The volume of each subject is 6.0 ECTS, so CC is in total 18.0 ECTS, and it lasts for one semester (16 weeks). The main form of studies is project learning. It is planned to involve graduates of previous years with whom the academy has traditionally good relations and who are usually in key positions in their companies and institutions. They are intended to play the role of observers and guest lecturers. During the CC, lecturers and students play through situations and try to solve problems, which can take place in the work of modern shipping.

Setting and completing tasks is made more complicated by bringing into play various influencing factors, some of them may be classified as expected (more or less) and some as unexpected. For example, expected ones may include the integrated digitalization of ships and ports, influencing of drastic climate change, and so on. Several global factors affecting the world economy as well as the state of local affairs, such as pandemics (why not?), major power outages due to various natural factors, etc., may be classified as unexpected.

Two additional factors favor the use of this methodology. Firstly, the curriculum “Maritime Studies” has two main specialties: Technical Exploitation of Ships and Navigation and Shipping Management, so that two professional groups can be selected within the study group: seafarers and shore personnel. It mimics the realities of shipping, where these groups are closely linked and cooperating with each other. Secondly, almost all students work on ships or in shore companies during their studies, which provides a good opportunity to link studies closely to real working life and solving the more real problems.
12.4 Conclusion

It can be said that education goes hand in hand with the major changes in the economy and social life; the only question is, who plays a leading role in this trilateral union? At first glance, it seems that education and closely related to it science is the initiator, activator, and guarantor of continuous development. In this paper, the author expressed his position that this may not always be the case today, i.e., some things may be “turned upside down.” Not always common sense and an understanding of what leads to what is winning; it is often the “money world” that dictates future solutions, including paradigms and directions in education.

Now the author’s third philosophical question: how can some destructive aspects of human nature be overcome? Moreover, could it be at all? There is reason to doubt that. Why have Adam Smith’s theory and other mainstream economic theories found such a fertile surface and flourished for centuries, even though it is clear that the economic system built on them is unsustainable and ultimately leads to a general collapse rather than a general prosperity? Is it not because it resonates very well with human qualities such as greed, ignorance, etc.?

Besides, people do not see anything they do not want to see; they just close their eyes. It will soon be 50 years since publication of the so-called Meadows Group report entitled “The Limits to Growth” [12]. Its content and the predictions of human development modeled in it were shocking. However, many, especially the political and business circles, did not want to and still do not want to hear about it; the global business-as-usual (BaU) scenario is continuing. We are now quite close to the environmental and economic collapse predicted in the report, but for the most part, it does not worry people.

A good example of human ignorance is the lesson of the coronavirus: for decades, scientists have warned that a global pandemic with very serious consequences is quite likely, if not inevitable. Did anyone pay attention to this? The pandemic came and no one was ready for it.

From all this, it can be a disappointing conclusion that (a) in the struggle between common sense and the desire to make more money, common sense does not usually prevail and (b) the most common (if not the only) lesson of all lessons for humanity is that no lessons teach people, society, and humanity as a whole anything.

The author sees the challenges in changing maritime education; it can no longer be taken as just a way of acquiring certain knowledge and skills. The educated person’s worldview and attitudes become important, or rather, what he or she decides to do with his or her knowledge and skills, whether he or she is able to see the big picture and assess the effects and consequences of his or her actions. This is not only a challenge, but it is also a problem.

Figuratively speaking, the time of just executors of orders is getting over. In fact, “smart machines” will more and more be taking over the functions of executors. However, humans are programmers of these machines, and humans will decide on how their wisdom may be used. Thus, the role of human wisdom increases
drastically, because the price of stupidity and other “nice” human qualities may be too high.

Author believes that the only means to make people smarter are right upbringing and smart education. Maritime education is no exception, and although those coming to study maritime education have already acquired their main worldviews and beliefs in their families and in secondary school, it is never too late. Maritime education institutions have a role to play in increasing the share of wisdom in the world, at least in the maritime affairs.

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