Knowledge Transfer in Postgraduate Research and Education

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ABSTRACT—*The purpose of this paper is to diagnose and suggest remedies for issues in postgraduate research such as lack in transparency, sharing and application of existing and newly created knowledge. A multidisciplinary team identified the critical factors in large industrial systems, the nodes that are the most amenable to improvement, and how can such improvements be actualized. An actual case of postgraduate research project was selected to present an important agenda recognized across the socioeconomic domains: how to contribute to the sustainability of large industrial systems. Key aspects included searching for information located in industrial databases, and exploring the pathways for two-way transfer of knowledge between academe and industry. The issues that might hinder the developing, sharing and application of newly created knowledge are identified as follows: ambiguous records of existing knowledge, isolationism in industrial databases, misalignments in the hierarchy of research priorities, communication circuit-breaks slowing down the application of research findings. This can be overcome by focusing on the inherent intentions and beliefs, and by improving the knowledge transparency due to the advances in the Internet and knowledge sharing networks.*

Postgraduate research and education can increase knowledge and generate innovation. Knowledge is a probability intensifier for contemplated actualizations. Something can be evaluated as understood only if significantly increases the probability of objectivization. The perspective of interaction between unmanned and manned systems, and the rise of the open networks for sharing interdisciplinary knowledge, present new avenues for enhancing the transfer and application of knowledge at unprecedented rates.

Keywords— Postgraduate, Education, Research, Knowledge, Transfer

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1. INTRODUCTION

Knowledge generation, transfer and application are key denominators of anthropogenic interactions within and beyond man-made systems. Systematic inclusion of all these components in postgraduate education has been broadly promoted. Hence, applied research ranks highly, and the actual utilisation of new knowledge in solving problems of practical importance is particularly encouraged. Contemporary issues of technological sustainability present prominent challenges that are increasingly addressed in postgraduate research projects. The volumes of already established knowledge represent a treasure that obliges the students to perform their research in an informed fashion – the keys to solving the identified problems lie in a competent understanding of scientific principles and theories. The core agent of this understanding – the learning – undergoes profound transformations within, and reaches potently beyond, educational establishments (Abhary et al., 2009; Kumar and Toteja, 2012).

Over the centuries, knowledge has been meticulously organised within the scientific and academic disciplines. Theories have been combined to highlight prime foci and to converge on similar classes of concepts following a hierarchy that serves to establish a (scientific) discipline. The major motive for grouping theories and hypotheses into scientific disciplines is to facilitate the storage, growth, communication and application of each specific category of knowledge. The academic educational streams (scholarly disciplines) were established following this categorisation, with an additional motive: to enable systematic learning, understanding and further extension of each observed class of knowledge. There are numerous classifications of disciplines used in academe and beyond; Figure 1 presents one example of possible groupings.

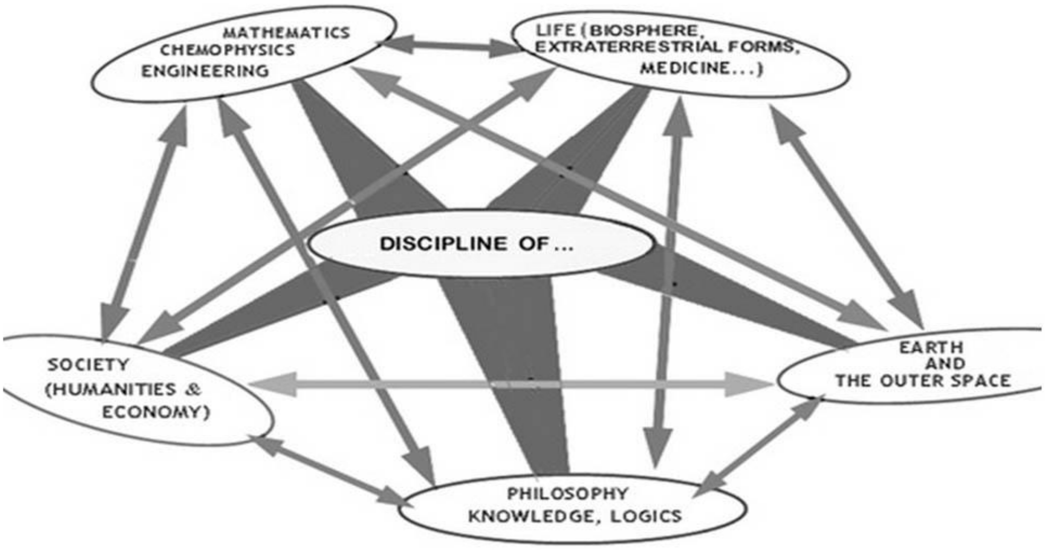

Figure 1: One way of grouping scientific disciplines

The purposes of learning and understanding can be reduced to our need to anticipate the anthropogenic and otherwise actuated changes. Our means of achieving this have advanced considerably; data processing in particular enables us to grasp and use more information than ever before. The question is, however, whether we are taking sufficient advantage of these new circumstances, and moreover, whether we in fact can afford not to. This class of approaches requires a shift in the existing paradigms that we have about learning and understanding, and their final destination – knowledge.

Prior to commencing actual postgraduate research projects, students have recourse to their previous education and, hopefully, also (some) professional practice. This is followed by a so-called literature review (constituting the background knowledge) which should assist in focusing their subsequent (re)learning of theories and skills relevant to a thesis problem statement. Notwithstanding the fact that all these phases recur during the actual research scrutiny, we shall temporarily focus on a question of what existing knowledge is supposed to be learned in this process. Before discussing how students are supposed to select such knowledge, it is useful to highlight some generic characteristics of the very concept of knowledge itself. Knowledge, in essence, is a probability intensifier for contemplated actualisations. Its structure can be visualised as a web of layers as shown in Figure 2.

The most immediate and tangible purpose of the above learning stage is not to amass the largest possible volume of theories assembled within one or a few disciplines. Such a compilation of comprehensive structures of knowledge strata is a long-term footprint marking the intellectual journey of entire civilisations; this objective has been continuously pursued by scholarly evolution resulting in encyclopaedic knowledge that is classified, sorted and recorded by means of academic conventions and networks.

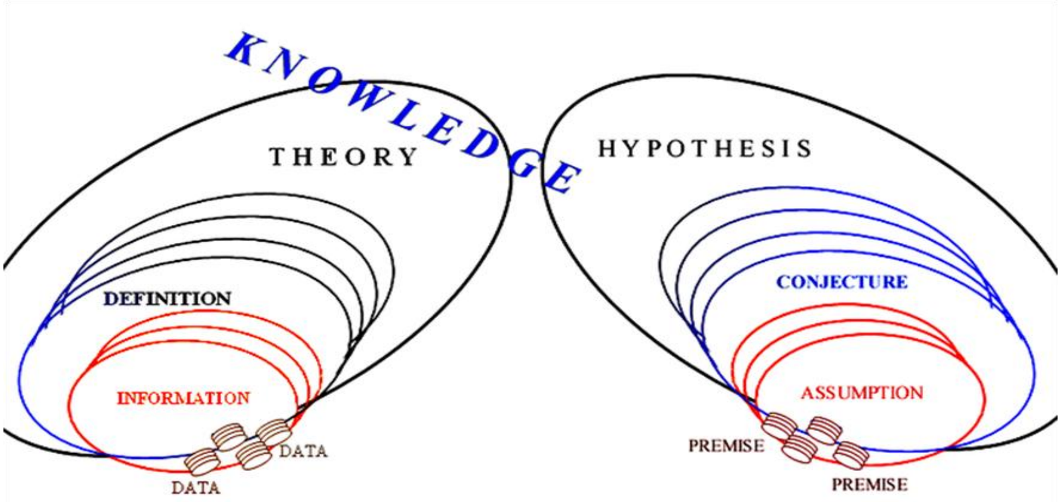

Figure 2: Knowledge structure

The learning embarked upon within a postgraduate project must converge about the central questions posed in the problem statement (which remains the heart of the dissertation). A good way of explaining this is the Law of Parsimony (Ockham's Razor). There is no need to always delve into the depths of the encountered theories – in some instances, data and definitions are sufficient. For example, a student might learn about the application of the analysis of variance (ANOVA) for the purpose of examining some published evidence. All that is needed is to learn the rules that must be satisfied when performing ANOVA and the logic of drawing the inferences (needless to note: the above is true providing that the actual research is not about improving the ANOVA method itself).

A PhD research problem statement raises questions that require novel, and quite comprehensive answers, and these answers are yet to be classified within the corresponding scientific disciplines and streams. Indeed, the meritorious solutions quite frequently present models that can be used in many disciplines. The ANOVA model, applied widely in science, engineering and psychology, is a good example of the development of a statistical method by virtue of applications in biology. Equivalently, the search for appropriate "background" knowledge must not be constrained by the boundaries of isolated disciplines and theories. In a number of cases, progress in solving complex problems is achieved by resorting to an interdisciplinary approach. For example, the recent advances in informatics such as genetic algorithms are inspired by, and founded on, our understanding of natural evolution in biology.

At the closure to this viewing excursion, a conclusion to land on can be summarised by the following statement: the source and scope of knowledge that is searched for are determined by the intent of the inquiry, not by the boundaries of some presupposed discipline. The clues for the possible solutions (which should correlate with the problem statement) can nucleate only if the principal questions are not let out of sight during the search across the domains and boundaries of scientific disciplines.

Due recognition must be given to so-called incidental discoveries and curiosity driven scientific research. However, this sphere of human achievements will be omitted in the present discourse. It is hard not to mention, however, that this kind of ventures is what distinguishes human intelligence from so-called artificial intelligence. It accounts for that unexplainable occurrence of "one additional step" in exploring beyond immediate visible achievements. Perhaps the analogy with estimating one additional digit, beyond the resolution of any measuring scale, could provide this with some rationale. The remaining explanations can be explored by analysing creative drive of fine artists.

Equipped with the above paradigms we chose a specific postgraduate research project as a case by which some issues related to knowledge transfer in postgraduate research and education will be illustrated. This case was selected to present an important agenda overwhelmingly recognised across the socioeconomic domains: how to contribute to the sustainability of large industrial systems. The problem statement was formulated as follows:

The ricocheting impact of anthropogenic explosion of our economies and other endeavours of growing populations currently endangers our ecosphere. There is a pressing demand to learn how to urgently decrease the negative side effects of major pollution sources on the global scene – the large industrial systems. Their representative actor, steel manufacturing, consumes enormous resources; for example, a conservative estimate is that the water consumption reaches 90 tonnes of fresh water for one tonne of a steel product (Ellis et al., 2011). The principal question in this research is how to further rationalise the steel rolling process, a key link in the steelworking chain, bearing in mind the environmental impact of this high-volume process which is involved in the manufacture of over 90 % of all ferrous products. What are the critical factors in this fabrication line, the nodes that are the most amenable to improvement? How can such improvements be actualised? In order to ensure that this postgraduate research is oriented to an agenda of actual significance, the aims of the project included searching for information located in industrial databases, and exploring the pathways for two-way transfer of knowledge between academe and industry. This in particular included an inquiry about the potential application of research findings in a real framework of industrial manufacturing in steel rolling mills.

2. THE GENESIS OF THE PROJECT AND THE ASSOCIATED ISSUES

2.1 Literature review in search for background knowledge

The literature search of the publications addressing relevant research and the state of the art including terms "rolling" and "steel" yielded for year 2012 over 2,400 titles, and for 2011 over 2,300. On average 2,000 titles per year were detected for the period of the last 5 years. Even when an assumption is made that 50% of these publications can be easily filtered out by narrowing the search criteria after including keywords such as metallic materials, iron, quality control or maintenance, this still leaves about 1,000 titles per year considering only the references published in English (Spuzic et al., 2013).

This task was additionally complicated by ambiguous presentations of research frameworks and results. Differing authors evidently use differing terms for identical concepts (synonymy) or identical terms for differing concepts (homonymy). The following are just some of numerous examples of nomenclature misalignments observed in scientific and engineering publications.

The fundamental term "material" is used with quite differing meanings. The WordNet (wordnet.princeton.edu) provides five options. The two most differing definitions include:

a) Material (n) is information (data or ideas or observations) that can be used or reworked into a finished form; "the archives provided rich material for a definitive biography".
b) Material, (n) is the tangible substance that goes into the makeup of a physical object) "coal is a hard black material"; "wheat is the material they use to make bread" (wordnet.princeton.edu).

The UNESCO Thesaurus provides the following descriptors (suggested as preferred terms): 'Audiovisual materials', 'Building materials', 'Composite materials', 'Dangerous materials', 'Reference materials', 'Materials engineering', 'Machine readable materials', 'Bookform materials'.

The same source recommends the following descriptor: 'International circulation of materials' with a scope note: 'Use only in relation to agreements that aim to facilitate the international exchange of materials intended for educational, scientific and cultural purposes.' (Spuzic et al., 2006; databases.unesco.org/thesaurus; un-interpreters.org/index.html)

Constructions such as "composite materials" have their synonyms. "Composite materials" are frequently termed "composites", which is in good accord with nomenclature that uses the expression "ceramics" for "ceramic materials" and "polymers" for "polymeric materials" (which unfortunately are often addressed a 'plastics' as well).

The term 'iron' is used inconsistently e.g. in two-word combination to denote so called 'cast iron' – a metallic material where the iron (chemical element) occupies the highest portion in a mixture where metallic phases are significantly influenced by other elements such as silicon and carbon. Reputable international institutions and scientific journals such as Materials Letters, Wear, Materials Science and Engineering, disseminate publications where further homonymic mutations can be observed such as 'white cast iron', 'grey cast iron', 'nodular iron', 'ductile cast iron' or simply 'white iron', 'grey iron', 'ductile iron', 'malleable iron' etc. (www.ductile.org/didata/)

The use of the term 'metal' is another example of homonymy. According to the basic scientific disciplines, metals are a well-defined and classified group in the periodic system of the chemical elements. Why then do we need to use confusing terms such as 'white metal', which is in fact an alloy. It is not a good practice to use the term 'metals' to denote 'alloys', as is done for example in sources (www.ductile.org/didata/) and (Noda et al., 2008).

The concept "vector" is well established in mathematics and physics by a definition stating that vector is an ordered i-tuple of numbers, where i = a natural number; this formulation is concordant with the use listed by the United Nations Multilingual Terminology Database (unterm.un.org). However, in publications addressing environmental aspects, "vector" is used with differing meaning:

- A bacteriophage, or another agent that transfers genetic material from one location to another. (American Heritage Dictionaries, 2007);
- A carrier, especially the animal (usually an arthropod) that transfers an infective agent from one host to another. (O'Toole , 2003)

Such conceptual misalignment is disadvantageous in communication involving civil engineering and environmental engineering. Concrete walls are constructed based on knowledge of mechanics, where the concept of "vector" presents one of the fundamental notions. Such walls can be built with cement containing an agent (a vector) that breaks down organic and inorganic air pollutants through a photocatalysis. (Abhary et al., 2009; Wagner, 2006; Amadelli et al., 2005)

Another homonym is the term "variance", which is used in the discipline of accounting to denote the difference between the planned amount of money (the budget amount) and the actual amount observed (in terms of realized revenues or costs). The act of computing and interpreting variances is called variance analysis. (www.jaxworks.com/glossary.htm; Brewer et al., 2005; Hansen and Mowen, 2005)

However, another discipline, mathematical statistics, defines the variance as follows: a measure of how spread out a distribution is; it is computed as the average squared deviation of each number from its mean; e.g. for the numbers 1, 2, and 3, the variance is:

$$\sigma^2 = \frac{(1-2)^2 + (2-2)^2 + (3-2)^2}{3} = 0.667$$

There exists an obvious discrepancy in these two mathematically defined concepts. For example, if the budget for some unit is AUD $ 107, while the actual cost is AUD $ 100, in terms of the accounting definition, the variance amounts to AUD $ 7. However, in terms of a statistical definition, the variance is 12.25. (Spuzic et al., 2005) This discrepancy can cause quite unpleasant surprises when contracts are compared to deliveries.

Yet another term – "phase" – presents a further example in this list of homonyms causing confusion in interdisciplinary communication. The following definitions can be found in "chemical", "physical", "computing", "general" and other dictionaries and publications:

a) "phase" (in chemistry): Any of the forms or states, solid, liquid, gas, or plasma, in which matter can exist, depending on temperature and pressure. (encyclopedia.thefreedictionary.com)
b) "phase" (in chemistry and physics): 'A homogeneous part of a heterogeneous system that is separated from other parts by a distinguishable boundary. A distinct appearance in a material that is identical in chemical composition and physical state and can be mechanically separated from other material, as is ice from water. For example, a mixture of oil and water is a two-phase system.' (encyclopedia.thefreedictionary.com; oxfordindex.oup.com; www.visualthesaurus.com)
c) "phase" is a measure of position along a cyclically varying quantity, such as a wave or a periodic vibration. Phase is measured as an angle (or as a number between 0.0 and 1.0) with respect to a fixed datum point; one complete cycle is equivalent to a phase of 360°. (oxfordindex.oup.com; www.oxfordreference.com)

A prime example is perhaps the homonymous usage of the term 'technology' notoriously used in interdisciplinary communication of knowledge. While Strawn (Strawn, 1982) defines 'technology' as the science of techniques, the Massachusetts Institute of Technology (MIT) publishes that their mission "is to advance knowledge and educate students in science, technology, and other areas of scholarship" (web.mit.edu/aboutmit/). Therefore one can conclude that technology' is one of the scholarship areas that can be distinguished from sciences. Other sources embrace within the concept technology' actual techniques', including the pertinent materials, tools, equipment and other means for achieving a certain aim. For example, The Economist Newspaper reports on a manufacturing advance that "squeezes the latest digital technology into a manageable package of 13 kg." (www.natcorp.ox.ac.uk)

Numerous other sources use the term technology to address an application of techniques, system of techniques or technical assets. Massachusetts Institute of Technology has published on the MIT website (www.natcorp.ox.ac.uk) concerns such as "There is no settled definition of technology!", while Engineers Australia on its website (www.engineersaustralia.org.au) warns that "... the use of the term technology is often misleading and confusing." There is a significant difference in offering new materialised resources (e.g. tools or equipment) along with the instructions for usage, compared with only offering specific knowledge (e.g. definitions, intelligence and instructions) without supplying any materialised tools, energy or other chemo-physical resources. (Abhary et al., 2009)

Without entering in the discussion into inconsistencies such as the use of terms "roll" and "roller" as synonyms for the key tool in rolling mills (while textbooks in mechanics define roller as a component of bearings), it is educative to note that the above examples are selected from the list of fundamental scientific and engineering concepts.

Bearing in mind the importance of knowledge transfer, it is perplexing that the above misalignments are not taken care of. Especially when considering that the remedies are quite straightforward, as presented by numerous authors (Spuzic et al., 2013; Spuzic et al., 2006). The confusion and the waste of resources that are caused by the above discrepancies in principal nomenclature are in particular harmful at the sensitive introductory stage of a postgraduate's work, during the literature review based on the key words. Why this issue is so persistently ignored by the scholarly strategists and editors of scientific and educational publications is very surprising.

2.2 Issues with applicability of present knowledge

Yet another aspect of the above literature review points at a presence of quite an extensive range of publications addressing the themes of interest for the project; however, it appears that theory-centric and deterministic approaches dominate. The quantity of this class of published theoretical works is impressive. However, the resulting models do not offer sufficiently close approximations to real actualisations and, in many cases, they fail to include all significant variables. It appears that idealisation of experimental designs and resulting deterministic models undermine their service as possible realisations in practice.

Theoretical derivations and idealised experiments are caught in the trap of the first principles and so-called natural laws. Practical applications (empowered by today's improved detectors and sensors) indicate that the "laws" hold only under limited circumstances that often do not reflect the real situations of practical importance. For example, it has been observed that recent findings in nanotechnology have opened completely new perspectives on many scientific disciplines (Schommers, 2014). A popular example is evidence about elements that have been known for centuries as non-magnetic bulk solids, showing magnetic attributes when their structure is configured at the level of nanoparticles.

Complex mathematical formalisations appear to serve only for the self-purpose of theory itself – not for the purposes of practice, i.e. for solving the problem as it has been stated. As explained by Griesemer (Griesemer, 2013): "A theory does not count as formalized unless its presentation in a conceptual notation is actually used in these practices. In other words, formalization is a practice, not merely a state, property, or condition of a theory. Successful formalization affords increased facility or even makes possible new kinds of theoretical and empirical practice (that were) unavailable without (such) formalization."

Theories of physics of solids, continuum mechanics, elastoplasticity and thermodynamics provide the grounds on which the industrial processes of rolling are designed and constructed initially. Various deterministic methods, such as finite element/difference modelling (Byon et al., 2009; Yuan et al., 2006; Kwon et al., 2009) and slip-line-fields (Klarin et al., 1993) continue to be developed in an attempt to further optimise the rolling process. Yet, since these methods alone did not provide a sufficient shift in the optimisation effects a combination with other "competing" approaches is needed. The practice of rolling operations continues to outstrip our theoretical understanding of it. This means that costly corrections and trials must be undertaken at the resource-consuming industrial scale by engineers who are under an increasing pressure to realise significant improvements.

Concepts based on the deterministically calculated variables such as friction coefficient, strain rate and temperature do not allow for optimisation in the actual deformation zone. In the process of rolling, most factors not only vary across subsequent passes and within each forming volume, but also fluctuate during the course of the production series. For example, the friction coefficient (a parameter used to "explain" why and how the plastic forming by rolling takes place at all) changes dramatically with the conditions along the tool – steel interface (the surface of the roll grooves). Furthermore, the intricacy of the roll groove geometry introduces additional complications to the fact that all factors change both along and across the deformation zone.

In this scenario the information about the multifactorial correlation between the critical dependent variables and actually independent and controllable parameters is decisive. The knowledge of how we can affect the outcomes within the scope of real controls must be ranked highly in the hierarchy of modelling of the rolling process.

The complexity of these interactions hinders our understanding of the critical phenomena. It appears that the solutions must be sought for by virtue of data mining, based on the understanding that large sets of measurements allow for the recognition of the logical patterns inherent to the observed phenomena. Reliable avenues for improving steel manufacturing processes can be traced by means of extracting knowledge accumulated in the industrial and otherwise published data bases. (Abhary et al., 2013)

2.3 How to obtain the necessary resources?

Real manufacturing processes such as the steel rolling mill operations involve complex interactions of a large number of variables. All of these variables fluctuate chaotically, more or less dynamically, and hence the results can be predicted only within some tolerance limits. In some cases these fluctuations are so fast and unpredictable that the system must be operated by means of so called closed-loop controls. Although the sensors, actuators and the logics of such loop control are constructed based on exact scientific theories, the key principle of their overall operation is based on the so-called "black-box" principle. We do not need to know necessarily exactly why the output changes due to other factors, as long as we know that by changing a limited number of the input control factors we can compensate for significant changes. The prerequisite for this is to define the system operation statistics, which are ultimately estimated by means of a statistically significant number of repetitions. The relevant principles are summarised under the frame of stochastic theory.

The published stochastic models are applicable to solving new problems only if sufficient information and a data base are available. Knowledge extraction from large data bases is a widely recognised strategy that has gained considerably in efficiency due to the availability of rapidly improving information processors. However, published sources providing such databases are rare.

One solution to this issue is to resort to actual experiments in order to validate the predictions provided by complex models. The theory of experiments, such as fractional factorial design, provides us with quite rational procedures that can serve the purpose within the really available time. At this point it is educative to note that the large-scale repetitive processes such as manufacturing by rolling can be analysed retrospectively as if they were in fact multiple experiments.

Therefore, for the purpose of our research, a number of attempts were made to share in such data bases with institutions and companies that are involved in similar research and fabrication. However, this series of attempts did not result in our obtaining the respective permissions.

Attempts to embark into relevant funding schemes failed mostly at the initial stages of the formal application process, in spite of the relevance of the problem statement. The fact that the background investigations provided evidence in support of continuation of the proposed research continuation did not attract the support of the selection panels. Efforts to establish links to regional industry via the university owned commercialisation arms (established to assist at early stages of seeking funding) also failed to yield any progress. A typical response was that the prior art has covered the solutions to the proposed problem statement to an extent that the proposed research does not present as sufficiently novel.

The researchers involved in the discussed project decided to check this. A literature survey did not reveal verified solutions to the stated problem. On the contrary, there is growing evidence of the problem escalating. In the scientific literature, there is a strong consensus that global surface temperatures have increased mainly by man-made processes. No scientific body of national or international standing disagrees with this view. (Cook et al., 2013)

The process of steel making itself is highly energy and fossil fuel intensive and therefore the cause of environmental concerns across the world. The manufacturing process involves myriad operations which may contribute to three basic sources of pollution i.e., of air via volumes of emissions, of water via discharge of liquid effluents and of soil via disposal of solid wastes (planningcommission.gov.in). This calls for further rationalizations in all segments where this is possible, an activity which implies that we understand and control the relevant processes.

In addition, since the proposal addressed the novelties in rolling mill technology, the researchers contacted an international professional organization for rolling process designers and rolling mill engineers AIKW (www.aikw.org). The AIKW board evaluated the proposed research as a novel contribution and invited a lecture on this theme to be presented at their annual international conference. This conference was attended by representatives of steel rolling industry and research institutions from all around the globe.

The initial contacts with multinational steel manufacturing companies that operate large rolling mills in Australia indicated clear interest in the project. The same interest was received from one of the largest steel manufacturers in China. However, this latter interest was followed by a request to provide pilot results of trials conducted by rolling steel samples at temperatures above 900°C. Applications for financial support for such a pilot demonstration from the domestic funding institutions were unsuccessful. The same unsuccessful outcome resulted when several Australasian universities were invited to consider collaboration – the targeted academic institutions operate laboratory rolling mills that are equipped for appropriate hot rolling tests. However, it appears that they have other priorities for the use of these facilities.

Communication with potential industrial stakeholders in the region was met with initial interest that advanced only to a point where access to industrial data bases was requested. The contacted correspondents exhibited an interest in receiving, however, not in providing, information.

In order to progress the project, several overseas companies were contacted, and one Asian manufacturer responded by providing both the information and the physical samples. This has enabled further advancement in the research and, based on these results, the project has attracted the interest of several research institutions from universities located in Europe. A series of pilot trials (rolling of steel samples at 1000°C) provided further supporting evidence in favour of the proposed research. Joint research proposals are now being developed in collaboration with the EU located Universities. This development is now endorsed by one steel manufacturing multinational company that operates several rolling mills in Australia.

This development has been presented to the home institution to promote this opportunity for inter-academy collaboration. The internal response to this promising collaboration is, however, still awaited.

3. ROOT CAUSES OF OBSTACLES

A reflection on the possible causes for this state of affairs resulted in the following thoughts:

The boundaries between the disciplines are unreasonably enforced by surrendering to an idea that the actual research problems must be classified within specific intellectual fences. Based on such illusion, the solutions are sought for within a limited area of knowledge. This isolationism is well illustrated by the inconsistencies in scientific nomenclatures. Misalignments in principal scientific terms do not appear important to those who never look for knowledge and answers that might be available in other disciplines. An important part of the mission of universities is in fact to remove this category of hindrances and to enhance the transparency of universal knowledge. This certainly requires the encouragement of interdisciplinary knowledge transfer.

Within the institutional fences, knowledge transfer is officially strongly promoted. Yet, in the presented case these declarative commitments have not been sufficient and there is a need to address the core issues such as root beliefs and resulting intentions. For example, a belief that the knowledge should be kept confidential and intellectually protected instigates isolationism that blocks exposure to, and verification of important concepts, theories and hypotheses.

It appears that it was easier to attract collaboration from overseas (European) universities compared to the Australian institutions. Analogous outcomes resulted when contacting domestic (Australian) and overseas industry. Could this be a consequence of local competitive impulses outweighing the prospects of knowledge transfer synergy?

Socio-economic systems can perform quite differently depending on how they communicate knowledge. Working towards a common goal requires sharing perceptions, intentions, beliefs and knowledge. Looking at a local scale, there are known educational institutions and industrial organisations that have suffered financial losses due to the lack of dialogue between the antipode experts, each protecting their area of knowledge. Such policies of intellectual protection and confidentiality safeguards have resulted in hindering learning and application, as well as in the loss of expertise. This aspect is well illustrated by analyses showing that enterprise costs can be reduced up to one third by fostering trust and information sharing. (Abhary et al., 2009a; Seidman, 2007)

A belief diametrically opposite to the idea of confidentiality is that the efficiency, growth and validity of knowledge increase with the quantity of the informed participants. The importance of knowledge disambiguation extends beyond the scope of any discipline, and the limitations of any single culture. Once the importance of sharing and application of knowledge is recognised on a more global scale, the issues such as ambiguous and confidential information will become exposed thus triggering the energy needed for activation of the mitigating processes. The appropriate framework for these progressive trends is enabled by the development of databases and networks such as Web of Knowledge, universal information systems that are omnipresent in knowledge dissemination on the global scale. In this new environment the mission of academe should include promoting knowledge transparency, shared beliefs and constructive intentions. In turn, this will lead to reduction of the environmental deterioration.

In the case presented in this discourse the home university has an opportunity to improve its academic standing in applied research focused on critical issues in important industrial systems. The substantial financial and other resources have already been invested in the pilot stages of this research and there is an opportunity in formalising collaboration with other academic institutions concerned with this category of research. Although the home university operates significant equipment and infrastructure, these facilities need to be used in combination with those of collaborating institutions and industrial partners, both in Australia and abroad. Bearing in mind the urgency of the rationalisation in resource consumption by the targeted industry, the presented agenda can be summarised to a question as to whether the promoted priorities in postgraduate research need to be subject to more farsighted and prescient scrutiny.

4. CONCLUSIONS

Technological expansion has knitted the Earth's ecosphere with man-made constructions that facilitate complex industrial processes which multiply with increasingly unanticipated results. The intricacy of these anthropogenic operations is extraordinary, and our present knowledge does not allow for confident predictions of certain immediate, not to mention the long-term, consequences. This highlights a need for expansion of our knowledge by means of postgraduate research. In this discourse a reflection about the nature of knowledge itself has been introduced in order to provide a better understanding how applied research and knowledge transfer may be obstructed in the case of postgraduate work.

This discourse has illustrated some important issues that hinder postgraduate research based on the case of a project focused on mitigating detrimental impacts of environmental pollution caused by large scale industry. A view on research conditions was projected on a selected technological scene – steel manufacture – that is increasingly overshadowed by the harmful effects of its own by-products. A focus on solving problems of practical importance can be highly rewarding for postgraduates despite the obstacles alluded to. Although new avenues are available for learning about, understanding and hence mitigating the disadvantageous processes such as global pollution, a conditio sine qua non is to select appropriate research priorities, commit to interdisciplinary collaboration and adopt an open transfer of knowledge.

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