BRIEFING NOTE

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On Insight-Oriented Learning Strategies and Curriculum Design

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As we have deliberated the design of tertiary-level curricula, it has become clear that the general regional university policies to "semesterise" curricula and use the credit system to constrain aggregate student workload entail a significant shift in the underlying operational philosophy of our region's tertiary education programmes.

This is consistent with the ongoing stress on shifting to student-centred learning and the consequent stating and assessing of learning targets as specific competencies to be achieved. However, it is now also apparent that there is a need to strike a balance between such detailed learning targets and the role played by broader integrative instructional goals, activities and units, not just in Capstone courses, but starting from the initial stages of our programmes. In turn, this need implies a shift from our traditional focus on narrowly specialised recall-oriented instruction/training to the emerging paradigm of integrative, insight-oriented learning designed to develop technology practitioners who both have appropriate depth and that breadth that leads to flexibility and synergy in work teams.

It is therefore appropriate for us to now consider the validity and value of integrative, insight-oriented learning strategies as a way to develop effective, student-centred curricula for our semesterised programmes.

1. The Role of Understanding in Learning, especially for Technology

It has been observed that "knowledge without application is fruitless; skill acquired without understanding will fail in an emergency." [Adapted; Nancy Catty.] This succinctly states the basic tension faced by technology-oriented programmes: how to promote insightful learning in an applied/practical context, where technology growth is driven by the three to five year generational cycle of the key technologies: microelectronics and information technology.

In this context, quite literally, half — or more — of the technology content of a four-year degree programme may well be obsolete by the time a student completes his/her studies, multiplying the pressure on our curricula to cover more and more content and complexity in the fixed window of time available for a Diploma or Degree. In short, the traditional "memorise and reproduce"-oriented approaches to teaching technologies — which implicitly assume that technologies are relatively simple and static — have been rendered obsolete by the very dynamism that now makes Technology such an attractive field of study.

"Life-long learning," "flexible specialisation," "independent learning" and "student-centred learning" strategies have all been proposed as ways to address these trends. A moment's reflection will suffice to show that such strategies are clearly correct. However, each of these is critically dependent on a paradigm shift to insight-oriented learning, as it is depth of understanding that give the confidence, flexibility and independence of mind that are critical to each of these strategies.

Therefore, our understanding and application of the nature, structure and process of understanding as a psychological/educational/practical process are critical to the success of our curriculum restructuring project.

2. What is Understanding?

Richard Skemp defines: "to understand something is to assimilate it into an appropriate [conceptual] schema." Unpacking this definition will take us to the heart of the issue and potential of integrative, insight-oriented learning strategies:

- Concepts are the basic building blocks of insightful knowledge. They are formed as we observe, group and classify common patterns in our concrete experience of objects in the world: for instance, a chair. Soon, we will recognise further instances/examples of such a concept, and may use definitions to increase its precision by clarifying its borders. Next, we may continue the process of abstraction, forming higher level concepts from the lower, more nearly concrete ones. For instance, chairs, shelves, chests of drawers etc. lead to further concepts: furniture, artifacts, etc. [Cf. Skemp, Ch. 1.]

- Since one concept can therefore cover indefinitely many instances, objects and experiences, concept formation helps us to economically, logically and flexibly describe, classify, interpret/explain and master our world. Thus, it is the first step to understanding.

- Concepts, however, do not stand in isolation; they tend to be linked in networks of related concepts, such as: position, displacement, speed, velocity, acceleration and jerk. Such networks of concepts developed through interaction with the environment and "represent[ing] the world as one knows it" are termed schemas or schemes. [Yount, p. 75.]

- As we continue to encounter new experiences, we typically try to assimilate them into our current schemas, by interpreting the experiences so that they may fit into the schemas, which therefore tend to grow.

- However, sometimes our schemas are not adequate to a new experiences, and may lead to distorted perceptions of what we experience, or even to "filtering out" what does not fit into our mental frameworks. (This is the basis for many of our misunderstandings in education and in life.) [IBID, pp. 78-79; cf. Skemp, p. 41.]

- Accomodation is a more complex adaptive process than assimilation: 'adjusting schem[as] to fit what we experience.' [Yount, p. 79.] Thus, it allows us to develop or transform our schemas in light of new experiences, instead of warping our perceptions and experiences to fit an inadequate mental framework.

- But, a schema "is of such value to an individual that the resistance to changing it can be great, and circumstances or individuals imposing pressure to change may be experienced as threats — and responded to accordingly. Even if it is less than a threat, reconstruction can be difficult, whereas assimilation of a new experience to an existing schema gives a feeling of mastery and is usually enjoyed." [Skemp, p. 42.]

- As a result, the appropriateness of our schemas is a critical educational issue. "We may achieve a subjective feeling of understanding by assimilation to an inappropriate schema — the Greeks 'understood' thunderstorms . . . [in terms of] Zeus, getting angry and throwing things. In this case, an appropriate schema involves the idea of an electric spark . . . The first and major step was taken by Benjamin Franklin, who assimilated concepts about thunderstorms to those about electric discharges." Not surprisingly, "One obstacle to the further increase of understanding is the belief that one already understands fully." [IBID, pp. 43 - 44.]

- Thus, understanding — as opposed to *mis*understanding — requires accurate correspondence of our concepts, schemas, perceptions, reasoning and experiences to the actual state of affairs in the world. Given that "to err is human," we must therefore always be open to correction in light of new evidence. This is another reason why a good exposure to critical thinking is a vital part of tertiary *education*.

So, by "unpacking a definition," we have been able to elucidate the nature, structure and process of understanding: assimilation of new learning into appropriate conceptual frameworks. Equally clearly, insight-oriented learning strategies must:

- "start where the learner is"
- expose him/her to stimulating concrete experiences to enable concept formation,
- foster the formation and growth of appropriate schemas, and
- cultivate critically aware open-mindedness so that students will not mistakenly believe they have cornered the market on the truth, and will accommodate their schemas as required.

As the process unfolds, the building of a progressively integrated framework of knowledge will start slowly, but will clearly accelerate, as the cumulative knowledge base will allow learners to assimilate new learning at ever-faster rates. This is because the more one knows, the more one can learn.

By contrast, if one relies on memorising facts, rules and procedures, "the number . . . becomes steadily more burdensome until eventually the task becomes excessive." Unfortunately, "learning to manipulate symbols in such a way as to obtain the approved answer may be very hard to distinguish in its early stages from conceptual learning . . . The amount which a bright [student] can memorise is remarkable, and the appearance of learning . . . may be maintained until a level is reached where only true conceptual learning is adequate to the situation. At this stage the learner tries to master the new tasks by the only means known — memorising the rule for each type of problem. This task being now impossible, even the outward appearance of progress ceases, and . . . another pupil falls by the wayside." [Skemp, pp. 40 - 41, 48. He suggests that adaptability to new, though related situations will discriminate intelligent learning from "rote and regurgitate."]

Sadly, Skemp's analysis sounds uncomfortably close to the mark. Could this be what has been happening to many of our students?

3. Moving Towards Insight-Oriented Learning Strategies

Insightful learning is clearly vital to achieving long-term learning success, flexibility, adaptability and an ever-growing capacity to learn more in the face of the ongoing knowledge explosion; it is clear that our new curricula must be built on this foundation, or they will simply fail. The major remaining issue, then, is how to operationalise this paradigm in restructuring science and technology-oriented curricula in the Caribbean:

1. First, intake to such programmes typically comprise students who have done Maths, Sciences and/or Technology up to fifth form or sixth standard. For many, this

unfortunately means their knowledge base is still recall-oriented, not insight-oriented. Few will have had significant effective exposure to critical thinking.

2. Therefore, one major task of the bridging/first year curriculum is the triggering of an initial significant reorganisation of the conceptual framework of our students, through a careful emphasis on the integration of knowledge and on the open-endedness of human knowing. (This last is a key focus for General Education subjects.)

3. The next major aspect is the provision of enriching, stimulating experiences and opportunity for critical reflection on those experiences. One facet relates to General Studies, but this area also speaks to our Mathematical, Science and Technology studies, for concepts are formed in a matrix of experiences. Specifically, we need a strong concrete experience-oriented component: experiments, workshops, demonstrations, tours and field trips, videos, projects and case studies.

4. Given the need for an integrative component, we must attend to the close linking of such experiences with theoretical aspects of the curricula. It is in this context that I have suggested:

    - Using a coil spring as a model body in mechanics, to explore force, displacement, vectors and scalars, elasticity, work and energy, leading into momentum as the accumulated effect of force acting through time. Thence, we may explore Newton's Laws of momentum/motion, and the action of mass-spring systems and mechanical waves. (A slinky, serving as elastically coupled masses distributed across space, would be a useful tool for this; the fact that it is a rather compliant coiled spring would simply be a bonus!)

    - Kinetic Theory, the study of molecules as randomly moving particles obeying Newton's laws of motion, could also lead to a simple study of a piston at work. The simple derivation of the ideal gas law from these assumptions would give insight into pressure, temperature, Boltzmann's constant and the universal gas constant, thermal energy, heat and work, and even the basic entropy concept: that random molecular motion cannot wholly be converted into orderly motion , i.e. work. Such an approach would extend and deepen the concepts of Newtonian Dynamics, give key insights into Thermodynamics, and naturally lead to a basic examination of the internal combustion engine as an application of the concepts and principles.

    - When we turn to materials science, the coil spring can again be taken up. Suppose students wind such a spring from some copper wire. Loading then unloading it and reading the displacement of its movable end on a scale will soon reveal elastic and plastic deformation, hysteresis and the role of energy in deformation. This soon points to the heart of materials structure and behaviour; implying significant questions about material selection and processing for springs such as are used in many instruments.

    - Likewise exploring electricity by using a water circuit analogy, thus viewing an emf as a charge-pump, and loads as energy-conversion devices. Kirchoff's laws and the power relationship are natural implications. Linear models for Resistors, Capacitors and Inductors and the current and voltage source lead on to circuit analysis.

- In Mathematics, the Calculus can be introduced by studying the filling of a bucket under a standpipe, as we examine the link between flows and accumulations of flow. Engineering implications and applications are natural outcomes.

But, does this approach overload the proposed courses with too much content?

4. Content, Semesterisation and Overload

Skemp notes "if a task is considered in isolation, schematic learning may take longer. For example, rules for solving a simple equation . . . can be memorised in much less time than it takes to achieve understanding. So if all one wants to learn is how to do a particular job, memorising a set of rules may be the quickest way. If, however, one wishes to progress, then the number of rules to be learnt becomes steadily more burdenssome until the task becomes excessive. A schema . . . greatly reduces cognitive strain." [pp. 40 - 41.]

Thus, schematic learning starts slowly, but accelerates as the students' insightful knowledge base grows. Rote learning, by contrast, slows down to a grinding, frustrating break-down as the magnitude of the overall task becomes excessive, especially at the point where insight becomes an essential aspect of successful performance.

Typically, that is the point where higher order cognitive learning is needed: analysis, synthesis [which includes design], and evaluation, i.e. judgement. Such higher order thinking is critical to professional and technologist level engineering practice. Moreover, insightful learning — if it is to work properly — needs to be an integral aspect of instructional strategy right from the beginning. Thus, we should build such strategies into our curricula from the beginning, even if it means less content in initial units.

However, except for Chemistry, this will not be the first time our students are doing Mathematics and Sciences. As a result, there will typically be a basic familiarity with the subject matter — they have passed the relevant CXCs — though there will doubtless be gaps and a lack of overall integration of knowledge, resulting in weak on-demand recall and inability to effectively transfer what is known to novel contexts.

Thus, a quick review and linking of what is familiar — perhaps using case studies and computerised drill — leading into new material and further insight would be an appropriate choice, rather than full-blooded remediation. [This last would be better suited to those who have not succeeded in their CXC's, and, given the cost of using Lecturers, is probably not cost effective for universities to do.] In short, we may reasonably infer that adequate time is available to work with integrative insight-oriented learning strategies.

Moreover, we have to face the implications of moving from the traditional cluster of year-long courses, to a maximum of six courses totalling 15 -18 credits per semester, where each lecture hour and each three lab hours correspond to one credit. Weekly contact time also should not exceed 24 - 25 hours.

The first implication, very simply, is that the old style of programme is now infeasible, and arguably always overloaded our students, leading to a passive, recall-oriented learning strategy.

A shift to a much more student-oriented focus, where students will have to take a far more active role in their learning, is clearly required. Thus, new approaches to course design are indicated, to more strongly develop active, integrative, insight-oriented learning; which appears to be necessary, given the ongoing explosive technology evolution. The above are suggested as ways such strategies could be justified and implemented.

Concluding Remarks

A new paradigm is inevitable, given semesterisation and given the ongoing knowledge and technology revolutions; let us make the best of it. To that end, I have argued that the new paradigm should stress integrative, insight-oriented learning strategies as effective ways to cope. In examining the underlying issues: the nature, process, structure and application of understanding, we have seen that insight-oriented learning accelerates as it proceeds, but traditional recall-oriented ones gradually break down under the stress of cognitive overload in the face of ever-increasing content and complexity. Thus, the feasibility and desirability of the new approach seem to be justified. A shift to integrative, insight-oriented, student-centred learning strategies is therefore recommended.

References and Attachments:

1. Skemp, Richard. *The Psychology of Learning Mathematics.* Penguin, 1987.

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4. Memory: Structures, Processes, Controls. (Based on Information Processing Theory.)

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6. Engineering: "Practical" Skills/Proficiencies Bank.

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8. The Electric Circuit.