INSIGHT: Thinking Issues

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Supervision for Critical Thinking: Challenges and Strategies

Developing students' critical thinking abilities is a goal of most Universities and degree programmes. These may be demonstrated through the standard technical or written expressions that evidence insights derived through study. But, apart from the usual general platitudes or more deliberate formal statements expressed in terms such as graduate outcome statements, course goals and graduate profiles, are we really engaging in a form of wishful thinking here? Do we actually know how to teach critical thinking in its various forms? Is the usual 'problem solving' approach adopted in CS education equivalent or not? Does it really produce actively critical thinkers and reflective professionals [7]?

This column originates from a few recent supervision experiences that have caused me to reflect upon strategies that might help students develop a critical mindset. Broadly stated, a challenge for supervisors in the computing disciplines is devising a strategy that might help students navigate from mere *description* of a phenomenon, project, design or artefact, to a deeper and more critical *analysis* and *interpretation*. So what are the challenges facing supervisors and what approaches might help?

There is of course a large body of literature related to the teaching of critical thinking, and problem solving as generic skills [8,12], and arguments about the extent to which they can be taught independently or in the context of a particular course. Paul advocates "a 'both-and' rather than an 'either –or' approach to these issues" [12]. Grant relates Paul's definition of critical thinking to 'problem solving' in programming classes:

> "Critical thinking, also referred to as problem solving, reasoning, higher ordering thinking skills, can be defined as a 'disciplined, self-directed thinking which exemplifies the perfections of thinking appropriate to a particular mode or domain of thinking" [8]

But Paul's more character based view of critical thinking refers to 'traits' that students might internalize and exhibit:

> "As we come to habitually think critically in the strong sense we develop special traits of mind:
> intellectual humility, intellectual courage, intellectual perseverance, intellectual integrity, and confidence in reason" [8])

One strategy that I have employed for developing critical written expression, at both postgraduate and undergraduate capstone project levels, has been the use of article summaries and annotated bibliographies [3]. But in the course of grading these assignments, as earlier noted in [3], I have found that while students can typically produce a concise summary, it is at the level of *critique* where they appear to struggle. This led me to ponder is there a diagnosis for this condition? It could be framed in terms of the classical educational taxonomy of Bloom [2], namely that students can function effectively at the levels of *knowledge*, *comprehension*, *application*, but struggle as they move into the

higher levels of *analysis*, *synthesis* and *evaluation*. For instance how many times have we seen students present the results of their experimental or simulation studies in bland tabulations of data, leaving the task of interpretation to the reader. Findings, insights and conclusions remain to be teased out, so the student's work is only half done.

From the work of the BRACELet project [6, 11] we have noted that novice programmers often function effectively at the *procedural* level of the SOLO taxonomy [1, 14] (where they can exercise a routine in a step by step fashion), but find it a challenge to operate at the *relational* level (where a holistic conceptual grasp of a program must be achieved). It seems to me that this distinction equally operates at more advanced levels in the research project and degree context, where the ability to transcend *step by step description* to produce a *conceptually holistic critique* when reviewing the literature or writing up a research study demonstrates a qualitatively different and higher order of thinking.

On a recent visit to Professor Daniela Damian's Software Engineering and Global Interaction lab in Victoria Canada (http://thesegalgroup.org), I had the opportunity to deliver a joint workshop to the researchers in the lab on how to upgrade a conference paper to a journal [4], aiming thereby to directly address some of the noted issues with the conference centric CS publication culture [13]. A helpful structuring device to guide the participants was provided by the notion of a *structured abstract* as required by the Software Engineering journal *Information and Software Technology*.

> "A structured abstract should contain the following headings (as in-line or run-in headings in bold): Context, Objective, Method, Results and Conclusions. An abstract is often presented separately from the article, so it must be able to stand alone." [9]

Of course writing an abstract is ideally best done after completing the full article contents, but the framing provided by a structured abstract does help in directing the course of a paper, and providing a brief initial summation that can be subjected to constructive critique. In the course of drafting their abstracts Daniela neatly rephrased this structure and broke the essence of a research article down to the elements in figure 1 below.

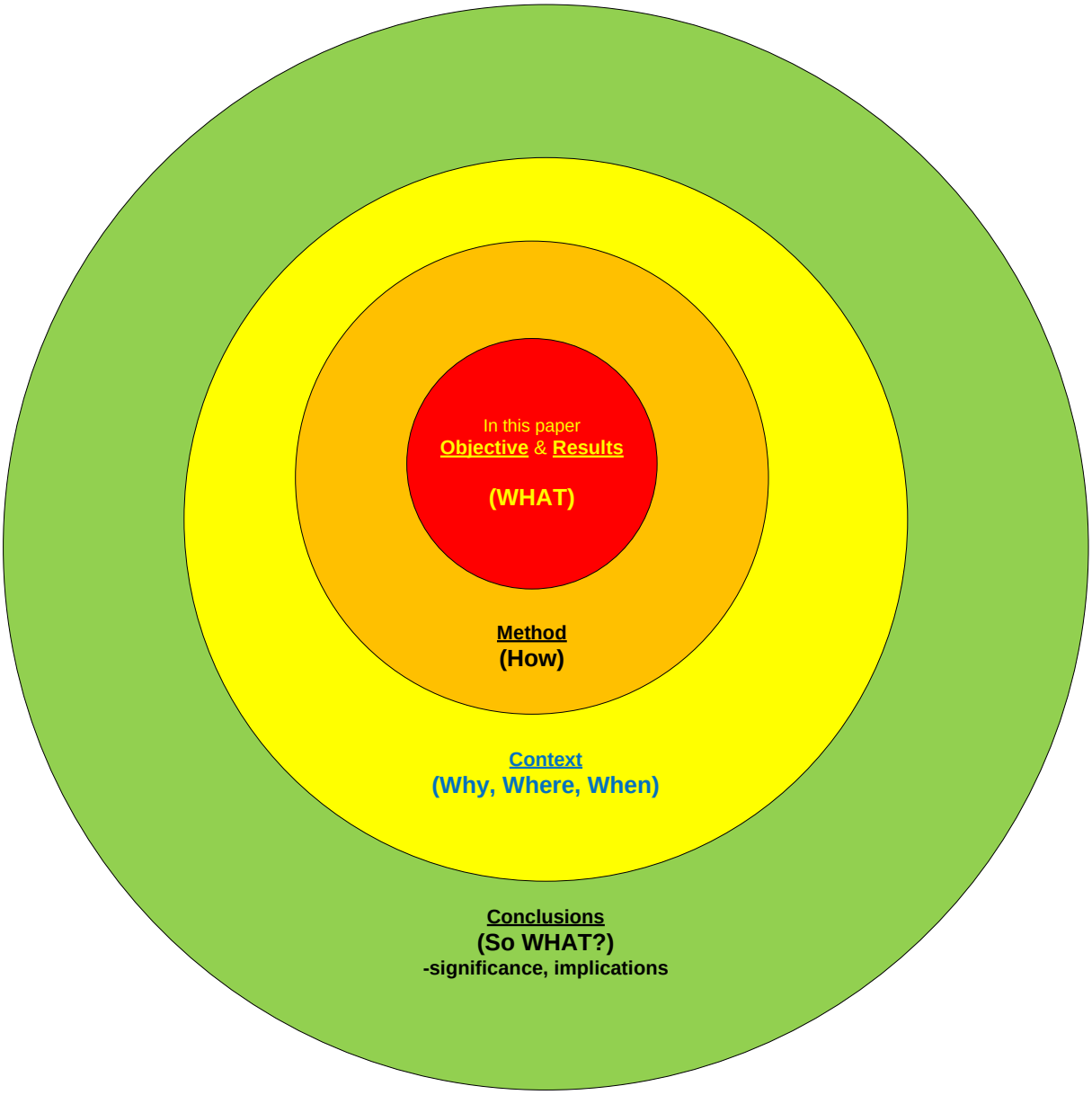

Figure 1: Essential Elements of a Research Paper (Damian, D, 2014 in [4])

There is nonetheless a significant challenge posed by each of these short words, which seem to demand different degrees of critical thinking ability. A clear statement of objectives often seems to pose a challenge, as does the process of elaborating the methodological aspects of a study. While explaining the research context would appear straightforward, answering the why question and clearly outlining the rationale can often be a stumbling block. Most challenging of course is answering the 'So what' question. Here the interpretation and teasing out the meaning of a paper has to be addressed. The process of working through these elements seems to be instructive, and maybe breaking down the elements in this way can help the process of thinking and writing critically. The *what*, *how*, *where* and *when* questions could be said to operate at the Bloom *analysis* and *synthesis* levels, whereas the *why* and

so what demand that students learn to *evaluate* material. This holistic form of production whereby students refine and distill the purpose and essence of their study findings, equally maps to the *relational* level of the SOLO taxonomy. Perhaps over time the cumulative effect of such exercises may help build in students a critical mindset.

When deep in the analysis for a doctoral study however, the process seems to demand a strategy of alternation between the particular and the whole in order to draw meaning from the data, through the 'zoom-in' and 'zoom-out' process of the hermeneutic circle [10]. Here the metaphor of *drowning in data* and periodically surfacing seems apposite. Yet how precisely to teach the process of drawing meaning from complex data, remains a vexing question. Apart from the divide and conquer techniques above and specific guidance in research methods and analytical techniques, sometimes it seems that these skills can only be taught by the intensive work of active mentoring by the supervisor and joint authoring with students. Joint authoring of course can be immensely satisfying, especially once the confronting exercise of receiving and responding to a set of mixed reviews has been navigated, and the final acceptance notification has been received!

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