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Educational Research for the Future

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Abstract

This review paper reflects on the findings of two major educational texts. These reveal some of the underlying principles that underpin aspects of learning. The two books also shed light on why much educational research today is making minimal impact, in terms of benefiting both teachers and learners. Although the two books start from very different perspectives, there is a considerable overlap in the findings they present, and offer common ground in suggesting ways forward in developing educational research of much higher quality. These books, along with the numerous references cited in them, offer a clear framework for the future. This review paper seeks to summarise some of the key findings, drawing in selected related literature as needed. The findings are relevant for teachers, teacher trainers, researchers as well as education policy-makers.

***Keywords*:** educational texts, fundamental research, research impact

Introduction

In 2020, two major books in the field of education were published (Kirschner & Hendrick, 2020; Reid & Ali, 2020). Both bring together the findings from research but are written from somewhat different standpoints. Both involve a practising teacher as one of the authors. One is written from an educational psychological perspective while the other from a fundamental educational research perspective. One focusses on schools in general, while the second is focussed more on secondary (ages 12-18) education, with some messages for higher education. While they do not cover exactly the same ground, there is a marked consistency in many of the messages/assertions they share with readers.

In the first book, the material is organised around 28 key publications from the field of educational psychology and cognitive psychology, under six broad headings:

- How the brain works and what this means for learning and teaching
- Prerequisites for learning

- How learning can be supported
- Teacher activities
- Learning in context
- Cautionary tales and the ten deadly sins of education

They note the neglect of many of the important findings in education today. For example, they observe that, *'... Vygotski's theory of the zone of proximal development and the idea that knowledge is socially constructed is a sine qua non in most teacher training courses while Baddeley s model of working memory is often omitted* (Kirschner & Hendrick, 2020, p. 10). They also note that. '*The single most important things that teachers need to know'* (Wiliam, 2011) *is cognitive load theory* (p. 10): however, this is rarely central (or even features) in most teacher education courses.

In the second book, the material is organised around the great research that has laid the foundation for our understanding of how learning (seen as understanding) takes place. It then looks at research evidence related to the way school curricula are designed and the central role of assessment. One area that is sadly neglected in most teacher education is the research evidence related to the development of thinking skills, attitudes and motivation, as well as practical skills. The book presents the worldwide evidence that shows the invalidity and meaninglessness of most measures of quality in education. Following a chapter that addresses the use and abuse of statistics in education, there are two chapters that consider many myths and mirages seen in education today, before suggesting some important areas for future research.

Both books are highly critical of the current quality of educational research and provide evidence as to what is wrong. In this, they follow the publications of others (e.g., Gardner, 2011; Slavin, 2002). Both are based on a collation of extensive research but the research chosen might be described as fundamental in the sense that it aims to uncover the fundamental principles related to key aspects of learning. Both have extensive sections where they collate evidence that undermines some of the many educational opinions that circulate today. In this, both point to clear messages, the first mainly addressed to teachers (and, by implication, teacher trainers) while the second also includes education policy decision-takers and education managers.

Bringing them together offers a rich agenda for some key messages for all those involved in planning, managing and delivering education today. It also shows some of the areas where research might be focussed in the coming years and decades. This paper seeks to bring together the two books, with other relevant evidence, to suggest some of the fundamental principles underpinning all effective and efficient learning, with a particular focus on learning seen as understanding.

Key Messages from Research

The Central Role of Working Memory in all Learning

The research underlying this is now simply enormous and a few key references are given in date order to enable the reader to follow through the development of research insights (Ashcraft, 1994; Baddeley, 1997; Baddeley, 2002; Baddeley, 1986; Gathercole & Packiam, 2008; Johnstone, 1997; Kirschner et al., 2006; Massaro, 1975; Miller, 1956; Reid, 2009; Shell et al., 2010). The research evidence comes from medicine, neuropsychology as well as educational psychology and psychology. It is largely ignored in education although there are several who have applied the ideas highly successfully in enhancing learning (Chen & Whitehead, 2009; Hussein & Reid, 2009; Johnstone et al., 1993; Jung & Reid, 2009; Pickering & Gathercole, 2004). Overall, there are hundreds of papers related to the central role of working memory in all learning and the picture revealed from these diverse sources is consistent (Shell et al., 2010). It shows the human being as an information processor and that the brain is designed to try to make sense of all that comes at us every waking hour of our lives.

The central finding is that humans undertake their thinking, understanding and solving of problems in that part of the brain known as the working memory, and that the working memory has a fixed and very limited capacity for each individual. The capacity grows with age until about age 16 and then remains constant throughout life (accidents and brain disease apart). Its limited capacity controls all learning seen as understanding. For this reason, teaching strategies do not hold the key to effective learning. What holds the key is the way any teaching strategy is employed. If it overloads the working memory, then learning deteriorates markedly. If it works within the capacity, then learning success is far more likely (Reid & Ali, 2020). Shell et al. (2010) describe working memory capacity as the '*bottleneck of learning*' (p. 13).

There is no need to measure the capacity (although there are well-established standard tests to do this) but it is vital that teachers are aware of the limited capacity, to know how to look for signs of overload, and to develop good ways to work within the capacities of the students before them. In fact, while most teachers are blissfully unaware of the central role of working memory, they have developed useful skills, simply through extensive experience, to help learners to cope well.

The Central Importance of Prior Knowledge and Understanding

Long ago, the research of David Ausubel laid the foundations (Ausubel, 1960, 1968). Kirschner and Hendrick (2020) make the key point when they state that '*What you know determines what you see and not the other way round*'. Overall, what a person understands and how they came to understand it controls future understanding. Being able to link new ideas to pre-existing ones (at a higher level of generality) is highly effective. Existing understandings provide an anchorage for new ideas and information. Thus, understanding is far more likely to be achieved if new material can be linked on to previous understandings, thus enriching these understandings. Reid and Ali (2020) summarise the enormous contribution made by Ausubel and link his findings to the work of other key researchers. It is worth remembering how Ausubel himself summarised the principle.'*If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly*' (Ausubel, 1968).

The Role of Language and the Visual in Learning

There is considerable evidence that many humans think in terms of words that create ideas and follow logical arguments. However, an even larger portion of population seems to think in terms of relationship between ideas leading to understanding. One of the great insights made by Miller (1956) is that the working memory not only has a fixed capacity that controls all understanding but the capacity can be described in terms of what he called '*chunks*'. A chunk is what an individual sees as a unit of information. The mark of the '*expert*' is that experience has enabled the person to bring together several items of information, link them together and see them as one *'chunk*' - one unit of information. Thus, they occupy

only one space in the limited capacity working memory, leaving the remainder of working memory for processing the information in some way.

If we think about it for the moment, a sentence can convey one idea but consists of numerous words which are related to each other. Similarly, a mathematical relationship can convey one idea but comprises numerous symbols. A diagram or graph can similarly convey one idea but consists of numerous interrelated components. The skill in employing the limited resources of working memory depends on our skills in being able to link ideas together so that they are *seen as one*- what Miller described as '*chunking'*. It does not appear that this skill can be taught but depends on previous knowledge and understandings as well as experience.

There is extensive research that has followed the original work of Miller. One of the areas considers conceptual learning. A concept, by definition, almost always involves synthesizing several ideas. Reid and Ali (2020) consider the evidence that explains why conceptual learning is so demanding. Conceptual ideas occur right across all subject areas but they tend to be introduced earlier, and more frequently, in subjects like mathematics, chemistry and physics. Understanding such concepts places high demands on limited working memory resources and that is almost certainly the reason why these subjects are often regarded as '*hard'* by young learners. It is interesting here to look at the brilliant research directed by Johnstone, mainly in relation to the teaching of chemistry. He showed that it was possible to develop a rigorous, and meaningful curriculum in chemistry that placed much fewer demands on working memory (Johnstone, 1991, 2000). One of the outcomes from this was that, where such curricula were followed (at least in part), chemistry (his subject specialism) became incredibly popular, with evidence of very high standards being achieved. A more recent example of this in operation can be found in the work of Hussein (Hussein & Reid, 2009).

Some of Johnstone's insights have been brought together, the principles applying much more widely than just chemistry (Reid, 2019, 2021). He also co-wrote a chemistry test-book where the central ideas of the limited capacity of working memory underpinned the entire way chemistry was presented. This book is perhaps unique in being based on a prescribed school curriculum but designed in such a way that took into account the research, of that time, in how learners come to understanding (Johnstone et al., 1981).

Kirschner and Hendrick (2020) consider non-verbal imagery as well as verbal symbolic representations, drawing out the research findings from Clark and Pavio (1991). This shows that verbal stimuli generate representational connections *in a verbal system* while non-verbal stimuli generate representational connections *in a non-verbal system*. This relates to what Baddeley (1986) had found in the way working memory operates.

Clark and Pavio found that things are remembered better if *both* systems are operated *at the same time*. Three clear conclusions have been demonstrated for learning:

1. Words and graphics *together* are better than words or graphics on their own.
2. Speaking and showing words is much less effective than words plus graphics together.
3. Words and visuals in close proximity are better than separated or at a distance.

Kirschner and Hendrick (2020) note that the evidence shows that, '*Everyone thinks with both systems and everyone benefits from using both. The more often you use the two systems together, the stronger the trace in your memory and the better you will remember and thus learn'*. They then move on to offer some very useful practical outcomes based on the evidence (pp. 47–49).

The Critical Role of Assessment in Learning

When we think of assessment, the normal reaction is to think of learners sitting at desks writing answers to questions given in an examination paper. This is a very artificial situation, and tends to be highly stressful for learners, as well as considerable amounts of burden on those who mark the scripts. Research reveals that there are several issues to be considered:

(a) For many, writing answers does not provide a good mechanism to reveal abilities and, as a result, examination grades are often seen by large numbers as '*certificates of failure*' (Reid & Ali, 2020, p. 167).

(b) Written examination papers can only measure a very narrow range of skills, and evidence shows that success relies heavily on memorisation and recall (Reid & Ali, 2020, p. 116).

(c) Typical examination questions are unable to measure many very important aspects of learning although there are some newer formats that can help (Ud-din et al., 2016).

(d) Assessment is typically employed to give access to the next course or level, thus removing those who are seen to '*fail*' (the majority, overall).

(e) At secondary stages, examinations are employed simply to select students for university and this reflects academic skills with other skills (often skills vital for wider society).

Both books strongly argue for better ways to employ assessment. One is the use of assessment to guide learning, often described as '*formative assessment*'.

Kirschner and Hendrick (2020) make a brilliant point about the value of regular testing, *used not to grade or assess*, but as a means of enhancing learning, as that retrieval process itself enhances learning. They show (Kirschner & Hendrick, 2020) that mastery learning strategies, coupled with formative assessment and support materials/activities, enriches learning greatly. However, they see formative assessment as a key part of a review process in which the learners gain feedback on what they have achieved and what needs to be addressed further. Many of the key principles are found in Black and Wiliam (1998) and Wiliam (2011).

Black and Wiliam (1998) define formative assessment precisely as, '*... encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged*'. This monumental paper reviews 681 publications from 1988 to 1998. This identified a number of key conclusions:

(a) The immense value of formative assessment relies on *quality* feedback.

(b) Formative assessment is not well understood by most teachers and is poor in practice.

(c) Both teacher role perceptions and classroom practice need major change.

(d) Pressures from local and national accountability undermine its efficacy.

This last problem is taken up by Reid and Ali (2020).

The Confused Literature Relating to Student-Centred Learning

The idea of student-centred learning has been floating around for the best part of a century but it grew and developed in the late 20th century. Much is based on assertion and opinion. Thus, for example,, it is sometimes argued that only self-discovered knowledge is meaningful to a student. The phrase can be interpreted in a wide variety of ways. For example, it may pertain to what is often called discovery learning, where students have a measure of freedom to pursue enquiry as they wish. However, it could be related to the way the curriculum is presented, with students free to choose the topics that they wish to study. In many ways, the teacher is no longer directing learning but is a resource to whom the learners may consult when needed. Under the general heading of student-centred learning are discovery learning, problem-based learning, experiential learning and inquiry-based learning.

Studies have explored the effectiveness of these approaches but findings often present a mixed picture, with some studies indicating advantages while others suggesting disadvantages. When this happens, it can often mean that some other variable is the key factor and that it depends on whether the way these approaches were implemented enhanced this variable or not. In other words, none of these approaches possesses any advantage in itself. It depends on how the approach is employed (Reid & Ali, 2020).

Kirschner and Hendrick (2020) draw attention to a key paper (Zimmerman, 1989). This study looks at self-regulation in learning and it relates to the desirable goal of encouraging learners to become independent learners. The evidence shows that allowing students to work independently is, paradoxically, a bad way to achieve this goal. Learners need direction, support and modelling. Evidence shows very clearly that the extent of self-regulated learning depends heavily on what the individual actually knows and understands in a specific area and the paper demonstrates the central role of teachers, parents and peers. This challenges the supposed benefits of student-centred learning. Kirschner and Hendrick (2020) look at the clear evidence that shows the benefits coming from direct instruction. This reflects the much earlier findings of Ausubel (1968) which were often ignored by the educational community.

In 2006, a paper was published in prestigious journal that shattered many of the assumptions made about student-centred learning (Kirschner et

al., 2006). This paper reviewed extensive evidence and showed what the key variable was that enabled learning to be enhanced, this explaining why student-centred learning sometimes brought benefits and sometimes hindered learning. The authors emphasised that the often-repeated assertion that direct instruction is less effective thanallowing learners to discover ignores the basic processes of human cognitive architecture, especially cognitive load and the limitations of working memory capacity. Minimally guided instruction challenges working memory and often inhibits efficient and effective learning.

Reid and Ali (2020) draw together the evidence from educational research that shows that the various forms of student-centred learning carry no advantages for learning when seen in terms of gaining knowledge and understanding. Indeed, they often place weaker learners at a significant disadvantage. However, when group-work is involved, there are advantages in the development of some skills and attitudes. Yet again, the key factor is working memory capacity. A recent book explores all this from multiple perspectives (Shell et al., 2010). This book is an example of the rigour that can be generated when evidence is brought together from diverse sources of research.

Areas Where Research Undermines Educational Fashions

Both books discuss many issues which relate to numerous educational fashions to be seen today. They bring together key research that challenges (or, in many cases, totally undermines) these fashions (Kirschner & Hendrick, 2020; Reid & Ali, 2020). Here are some of the topics explored:

Both consider the idea of '*learning styles*'. The claim is that, '*students adopt preferred styles in their learning and these styles can be measured, enabling a teacher to take the styles into account when teaching*' (Reid & Ali, 2020, p. 432). Large numbers of papers and books exist as well as a very lucrative industry selling supposed diagnostic tests, with training courses for teachers (Kirschner & van Merrie¨nboer, 2013). Kirschner (2017) has shown that evidence is lacking in four main areas:

- The actual existence of consistent learning styles.
- Learners being aware of this supposed style and able to report it.
- The idea that each learner possess an optimum learning style.
- Tailoring instruction to suit the style brings about better learning.

Overall, the research shows that there is no basis for these ideas. They are merely a human invention. Reid and Ali (2020) suggest a better way to consider the issue. The evidence shows that all learners come to understanding using the same mechanism, all built around the functioning of working memory.

Motivation is an important theme in many areas of life, including learning. The claim is that teachers can enhance motivation with their students, thus improving academic performance, it being possible to measure levels of motivation using questionnaires. Again, the literature is full of supposed '*measuring instruments'*, all based on self-report, and the studies often end up recommending that teachers should develop high levels of motivation with their students to gain better examination results.

First of all, questionnaires measure nothing but the collated opinions of respondents (Reid & Ali, 2020). The evidence shows how difficult it is for people to see themselves as they really are; thus, the validity of the questionnaire approach is under challenge. Secondly, using such invalid '*instruments*', it is often found that the supposed motivation correlates positively with examination performance. The assumption is the made that higher motivation leads to higher performance. It needs to be stressed that correlation does not imply causation. Kirschner and Hendrick (2020) show that the evidence indicates that increasing motivation does not cause success but that success, even limited success, can lead to enhanced motivation..

There is much assertion made about the young generation and their supposed skills with *new technologies*, leaving teachers behind in the digitisation revolution. Sometimes, this is related to wider opinions that there are 21st century skills which young learners possess. The argument is then made that we need to change education or, specifically, the way we teach. All this is based simply on opinion. Kirschner and Hendrick (2020) state, '*There's no evidence that young people today have any special skills (other than fast-moving thumbs) that would allow them to learn differently*' (p. 299). Reid and Ali (2020) refer to some major research. This shows that all humans learn in essentially the same way, new technologies merely being yet another set of useful *'tools'* which we can exploit helpfully. They do not change the way young people learn in any fundamental sense. The working memory is central and the information processing model, first developed by Atkinson and Shiffrin (1968) is widely supported. Indeed, the

fundamental structure of the model has never been undermined by any evidence. A modern version can be found in Reid and Ali (2020).

The idea of *problem-solving* appears widely in education documents and many curricula state that they seek to develop '*problem-solving skills'*. This implies that there is a set of such skills and that they are generic, allowing them to be developed in one subject area so that they can applied more widely. Firstly, there is a lack of clarity about the nature of what constitutes a problem. Thus, a problem in mathematics is very different from a problem such as global warming. Both may be very different from the kinds of problems we might encounter in subjects like chemistry and physics. The insightful work of Johnstone many decades ago has given us a way to classify problems that can be very helpful (Wood, 1993). This analysis applies much more widely than the original context. It builds on the seminal work of Hayes (1981).

Kirschner and Hendrick (2020) make the key point that the evidence shows that, '*without domain-specific and procedural knowledge, problem-solving becomes an exercise in trial and error*' (p. 301). They review the evidence and consider, in particular, the important work of Newall and Simon (1972). Similarly, Reid and Ali (2020) consider the research literature and note that what a person knows and understands *already* is critical to problem-solving success. The capacity of working memory is also critical. In other words, the belief that problem-solving involves generic skills which can be taught to learners is simply incorrect. Problem-solving is highly contextual in nature.

National and international testing is frequently employed to compare the performance of schools and teachers, often described as '*high-stakes testing*'. Reid and Ali (2020) review the worldwide literature. The evidence shows that this way to '*measure education*' generates a '*mismeasure'* (Horn & Wilburn, 2013). One of many problems relates to the fact that evidence shows that there are other factors which dominate in determining school successes in formal examination, factors that lie outside the control of teachers or schools. Reid and Ali (2020) conclude their review by stating, '*Research has shown that such tests are neither valid nor reliable while there is ample evidence of the damage they have done to learners and their teachers*' (p. 356). The evidence shows very clearly that such tests distort what is taught, do not measure numerous important skills and lack validity. The typical outcomes from such testing are summarised nicely by Robinson

(2011) as a deterioration of standards and the generation of disillusioned teachers.

Educational Research

Both books are very critical of current educational research practices, drawing attention to the weaknesses in current educational research and its methods. Kirschner and Hendrick (2020) focus on a set of key papers or books which have revealed *principles*, mostly drawn from educational psychology. By contrast, much educational research focusses on one set of data under *specific* circumstance and in a *specific* context. This is very similar to the point made by Reid and Ali (2020) that good educational research is characterised by being *coherent*. In other words, *principles* are uncovered by carrying through a series of studies. These can then be tested and applied in wider contexts to develop *fundamental principles*. '*One-off'* studies based on '*research proposals'* more or less undermine this essential feature of coherency.

Kirschner and Hendrick (2020), in introducing their book, state, '*This book is not meant as a set of stone tablets to be obeyed but rather as an introduction to a trajectory of thought on a particular area that will hopefully lead to more investigation of that area*' (p. 17). In similar vein, Reid and Ali (2020) summarise key things to avoid in educational research, as well as pointing to ways forward. Both books lay great emphasis on the need to develop our understandings of all areas of learning based on sound replicated evidence as well as looking for the *fundamental principles* that underpin all learning in all contexts. Reid and Ali (2020) outline the kinds of changes needed for future educational research.

It is possible to consider the nature of much educational research which rarely moves beyond the descriptive. Some aspect of the teaching and/or learning is explored, often employing little more than surveys of the opinions of relevant participants (questionnaires, interviews or focus groups). The researcher then recommends better ways forward for the future, However, supporting evidence is not offered to support these supposed '*better ways*', to show why they are better or even that they will generate a desired improvement.

By contrast, by focussing on fundamental principles, we are now asking questions that start with the word '*why?*' In a sense, most educational research today looks at *what* is happening but rarely does it move forward

to ask *why* it is happening in a particular way. It is here where the approach adopted by Kirschner and Hendrick (2020) is so powerful. They have focussed on 28 key papers which have been found to establish fundamental principles related to some aspect of teaching and/or learning. Thus, these papers are presenting insights into *why* things happen the way they do. When we understand why, then we are in a position to point to better ways forward, which, in coherent research programmes, can then be tested.

Conclusion

In considering these two books, we are drawn into some of the key research findings that point the way ahead in our understanding of many aspects of learning. One book focusses on 28 key publications with the publications that relate to them. The other draws on the research evidence drawn from over 600 research publications. There are numerous important research findings which should be underpinning all teacher education while the models of research described in the books point to better ways ahead for the educational research community. Perhaps, even more importantly, education decision-takers need to be aware of the findings from research so that future policies can be developed that are consistent with these findings. In this way, we shall be better equipped to move education provision forward on a sound basis.

Conflict of Interest

The author of the manuscript has no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

The data associated with this study will be provided by the corresponding author upon request.

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