Research in Science Education (2022) 52 (Suppl 1):S3–S13
https://doi.org/10.1007/s11165-022-10079-1

The Contributions of Peter Fensham to ASERA, *Research in Science Education*, and the Advancement of Science Education and Research

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Accepted: 4 November 2022 / Published online: 5 December 2022

Keywords Peter Fensham · Science curriculum · Science for all

Introduction

In our contribution to this special issue of *Research in Science Education* in honour of Peter Fensham, we seek to illustrate his unwavering capacity over 50 years to shape and advance research agendas in science education. We seek to do this by taking a specific focus on his research and writing in *RISE* related to science curriculum, clearly the area of science education in which he is most widely recognised. But before we introduce this specific focus, we will very briefly allude to the much wider spectrum of Peter's impact on science education research and advancement.

As already noted in the Editorial that appears at the start of this issue of *RISE*, Peter was a genuinely global figure in science education, with all of his research engagements, his own research, and his fostering of activity in so very many others, being focussed by the core commitments by which he actively lived all aspects of his life: equity and social justice, humanity and compassion. There is much about Peter's contributions to research in science education and the ways he was highly valued by and widely respected in the international science education research community to be found in Cross (2003) and Gunstone (2009).

Cross (2003) is an edited volume with the subtitle "Responding to the work of Peter Fensham". In this book, 15 academics from around the globe discuss Peter's key ideas of relevance to an area of their own research, and how Peter's arguments and proposals and recommendations have contributed to their own research. The chapters written by the 15 are grouped in the book into seven "Parts". The titles of these Parts speak to the breadth of Peter's research and impact: "Science for all" (see below for further consideration of this label), "Science, technology, and society: Learning for the modern world", "Gender in science teaching", "The theory and practice of science teaching", "Politics of the science

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curriculum", "Peter Fensham's reform agenda: The 'vision thing'", "Peter Fensham's impact … around the world."

Despite the remarkable breadth of Peter's work evident in just the titles of these parts of the Cross (2003) book, and the depth of Peter's work that is so evident from the detail of the chapters in the book, this list of Parts does not cover all the areas of science education in which Peter researched and wrote. For example, he was influentially and critically involved in the development and implementation of the two major international programs to compare student achievement in science (PISA and TIMSS), including research and writing that elaborated significantly problematic dimensions of these international comparative testing programs. And his concern with and thinking about Science Education policy, briefly alluded to elsewhere in this issue of *RISE*, was well underway in the 1990s when few others gave even fleeting thought to such a notion. (The importance of considering science education policy was the subject of the invited keynote Peter gave at the 1999 NARST conference, the conference at which he became the first Australian to be given the annual NARST Distinguished Contributions to Science Education through Research award.)

One of his wonderful and enduring science education legacies began in 1970, when Peter initiated ASERA, the Australian (for decades now, the Australasian) Science Education Research Association. The nature of ASERA and its significance for generation after generation of science educators have been described elsewhere in this issue. It does seem appropriate however to note that during the 2022 ASERA conference, just concluded as we write this article, the ongoing and most valuable egalitarian nature of the conference was succinctly pointed to by a tweet about the conference from a first time ASERA attendee who is still working on her/his doctorate; the tweet included "Nothing more exhilarating than finding your people!!".

As the founder of ASERA and a very strong contributor to the association and its annual conferences, Peter published a range of articles in *RISE* (which is of course the journal of ASERA). A full list of his *RISE* papers appears elsewhere in this special issue. When looking at that list, it is useful to remember that until the start of 1995 (the year of Volume 25 of *RISE* and the third year of Peter's nominal retirement), *RISE* was just a single issue each year, and contained only a refereed selection of ASERA conference papers from the year of publication, papers that were submitted to be reviewed after each conference. Thus, the magnitude of Peter's *RISE* contributions should be seen in light of this one-issue-per-year form that was only available to presenters of papers at that year's conference being the only form of *RISE* for the complete period of his formal academic work. (Almost all the years of pre-1995 *RISE* that do not carry a Fensham paper are years when Peter was somewhere else in the world—and, as his Monash colleagues at the time were very fond of teasing him about, he did travel a lot.)

Peter's *RISE* publications cover many of the wide range of his research areas we have noted above, specifically these publications consider learning (variously of chemistry, of science, of teachers, and reflections on a theory of learning), research methodologies, teacher development and teacher education, TIMSS, and curriculum.

It is Peter's publications on curriculum that are our focus for the remainder of this article, an unsurprising decision given the status with which his work on curriculum, in particular, has been applauded around the globe. Throughout all his work related to this broad field, Peter saw "curriculum" as being the broad construct that other researchers have—as comprising all of the often labelled "intended curriculum" (the formal description of "the path ahead"), the "implemented curriculum" (what was actually taught by the teacher, the path actually taken by the teacher), and the "attained curriculum" (what was learned by students in the class of that teacher, the path that the students actually saw that they experienced).

Peter Fensham, Curriculum, and *Research in Science Education*

The Editors of this special issue of *RISE* collectively agreed that the authors of this article should choose three of Peter's papers from past issues of the journal to be introduced and reproduced here, in order to illustrate something of the significance of his research.

We believe Peter's most widely recognised contributions to science education research and discussion are related to his advocacy of "Science For All", first laid out with supporting arguments and elaborations in another journal almost 40 years ago (Fensham, 1985) and reconsidered and elaborated in a number of his publications since. Core points about Science For All that Peter laid out in this first paper to advance his concerns and perspectives that led him to argue for Science For All are given in a separate section below. In what we believe is his most recent succinct elaboration of the notion, written just seven years ago, Peter describes Science For All as "an aspirational phrase that has repeatedly embodied the hope that all members of society, and in the particular case of education, all students, will be able to share in some way the richness of discovery, explanation, invention, and application that characterizes science as a great human endeavour" (Fensham, 2015b, p. 902). In this 2015 piece, Peter also notes the deeply ingrained and hostile attitudes, particularly of many university scientists and curriculum bureaucrats, to Science For All, but does so in a manner profoundly typical of this humble man—he first indicates that in 1847, an English surgeon named James Wilkinson was the likely first user of the phrase, Science For All. Peter then notes that Wilkinson also described the same kinds of difficulties experienced by Peter, essentially all forms of resistance to the sharing of the benefits of science.

The three Fensham articles from *RISE* we have selected to reproduce here all have, *inter alia*, significant antecedents to or elaborations of his thinking about Science For All; the first is from 1973 ("Reflections on the social content of science education materials"), the second from 1994 ("Progression in school science curriculum: a rational prospect or a chimera?"), and the third from 2016 ("The future curriculum for school science: What can be learnt from the past?"). We see these three as representative of his leadership in science curriculum thinking, and his agenda-setting for research in this field, as well as the evolving nature and breadth and depth of his curriculum writing in *RISE*.

We consider each of these articles in separate sections below, in temporal sequence. In each section, we first give some of our own thoughts about the article that we believe will assist the reader, including why we have chosen it. Then, the article is reproduced as it was when first published in *RISE*, with two exceptions: (i) a very small number of referencing errors and one critical typographical error have been corrected and (ii) the first two articles, having been written a significant time in the past (49 and 32 years, respectively), have some matters of context that are assumed to be familiar to the reader but are very likely no longer so. We have sought to solve this second matter by adding footnotes to each of the first two articles; please note these footnotes were *not* in the original publication of the article. For each of the three articles, we add some further comment after the reproduction of the original to conclude that section.

In addition, there are three further short sections below, where we consider three other Fensham publications that are part of his 'Science For All' story that underpins what we are writing. For each, we make some relevant comments but do not reproduce the original. These three publications are Peter's first Science For All article, in the *Journal of Curriculum Studies* (Fensham, 1985) (our comments are the short section immediately following that for the 1973 *RISE* article), the chapter Peter wrote for the book generated to celebrate the work of the late Rosalind Driver (Fensham, 2000) (our comments are the short section immediately following that for the 1994 *RISE* article), and the chapter Peter wrote for a collection with a focus on “The future in learning science” (Fensham, 2015a) (our comments are the short final section of the article).

Peter Fensham (1973) and Social Dimensions of School Science Curricula

Some Introductory Comments About This Article

In this article, Peter reflects on the results of a very early content analysis of several senior high school Chemistry texts/curriculum projects and junior (year 10 and below) high school general science texts/projects in terms of three social dimensions. We do not know precisely how much or how widespread globally such a research matter was investigated previously, but we believe it would have been very low. We are confident that, at least in terms of English language research reports, this article is an agenda-setting one.

We see the use of “Reflections” in the title of the article and the comments in the first paragraph as likely indications of the extent to which many of the relatively small number of science education researchers at the time saw research methods more in terms of traditional science research (with controlled variables and a goal of developing universal generalisations, and so on) rather than in the modes of science education research with which we are familiar today. We also see importance in the use of “Reflections” in that it is this mode of broad and thought-provoking generalisations that Peter’s research had so much impact by offering new insights to potentially lead other researchers into new and important explorations and thinking.

The social dimensions Peter considers in the analyses he reports in the article are “social nature of science”; “applications of science”, and “interaction of scientific knowledge with society”. It is important context to note that “applications” was in no way a novel issue for chemistry or science curricula in the late 1960s/early 1970s—there had been several manifestations of such a focus in different education jurisdictions around the globe, and at different times, since at least the late nineteenth century (in the Australian state of Victoria, for example, most recently for this 1973 article, in the 1950s). But these previous manifestations were always for text/curriculum that were developed by a focus only on the applications of science and the underpinning science needed to understand the application. What is different in the ways Peter considers “applications” is their consideration both in concert with the other two social dimensions and for texts/curriculum that were not solely focussed on and by applications as a means of understanding science concepts. It is consistent with many other contributions from Peter, both before and after this article, that he saw applications (uses of science) as part of science itself.

We interpret the findings in the Chemistry materials in terms of “applications” as possibly resulting from the past uses of applications in a different way, as just noted above. We conject that Peter’s conclusions that, while curriculum/materials produced by scientists were strong on content but weak on social aspects, those produced by teachers were more likely to be stronger on social dimensions, and may have some origin in the same previous modes of more narrow considerations of “applications”.

The reprinted article (Fensham, 2022b)

Further comment about this article

In Peter's discussion of the results of his analyses, he comments that some of the projects he analysed "were influenced by the particular philosophical approach known as the Structure of Knowledge". This interpretation is not supported by any of the contemporary descriptions of the projects as they emerged, by either the research scientist developers of the projects or by any other commentators. Much more importantly in this context, Peter himself certainly had quite different views about this matter later on. For example, Peter wrote very differently about the expert teachers involved in development of projects such as Nuffield Physics in 1982, where he linked these teachers with research physicists by describing them as "their [research scientists] faithful imitators, elite science teachers" (Fensham, 1982, p. 53). A decade after this article, in his remarkable overview of science curriculum research and development (Fensham, 1992) that appeared in the *Handbook of Research on Curriculum* generated by the American Educational Research Association, Peter discussed the senior high school curriculum projects such as PSSC Physics and CHEM Study Chemistry. In that discussion, he notes that "it is now clear that academic scientists exerted a crucial influence on the sort of science content that was included [in projects such as CHEM Study] as worthy of learning. They were important legitimators of what topics and what sort of account of them were appropriate for school science. Their exercise of this role…[was] more constraining in the physical sciences [than the biological sciences]" (p. 791).

As Peter wrote in a number of contexts after the 1973 article, the Structure of Knowledge focus of the first generation of curriculum projects (PSSC Physics, CHEM Study, BSCS Biology, and so on) was not so much a "Philosophy of the Structure of Knowledge" that he writes of in 1973; rather it was a focus by the academic physicist/chemists, etc., who developed these curricula on the "structure of the discipline", in part driven by the belief that adopting this approach would attract the best of senior students in US high schools into the study of the sciences. (So, for example, the reason for PSSC Physics including nothing about sound and relatively little about electricity is a "structure of physics" academic perspective that meant a decision that all the content to be included in the PSSC program would lead to a single endpoint: "wave-particle duality". Matters such as value to the everyday lives of students had no place.) Or, to consider the focus of this 1973 article of Peter's, the first-generation curriculum projects such as PSSC and CHEM Study had no concern in any way with social dimensions of science, and this shaped the whole of the nature and content of the curricula they variously produced.

Peter Fensham (1985) and His First Account of Science For All

Early in this seminal article, Peter notes his observation of a growing consensus in a number of countries that:

(a) We now have much better curricula for education in the sciences of those (about 20% of an age group) from whom the future scientists and science-related professionals will be drawn.

> (b) We have not achieved an effective science education in schools for the 80% or so who most probably will not continue with any formal education in science after they leave school.
> (Fensham, 1985, p. 416)

In reflecting on group (b) in the above quote, Peter describes the societal demand for a more scientifically literate citizenry as meaning "a science education should produce more members of the society who will be able to benefit from the personal and social applications of science and will be prepared to support the changes of a scientific and technological kind that are needed for a good balance between development and environmental concerns" (1985, p. 417). This is consonant with many definitions of scientific literacy, particularly the practical and economic aspects often cited.

Underpinning this argument is his skilfully summarised consequences of the Discipline Structure focus of earlier science curricula and the effect of the burgeoning student enrolments in the upper years of secondary schooling. For 80% of them, the prevailing knowledge-based curricula are not only unsuitable but off-putting for students to develop any sense of a relationship with science, something that needs to come from science-societal links. (Note: "any sense of a relationship with science" in the immediately previous sentence are not Peter's words, although we certainly see them as a most valid way of representing much of the core of Peter's arguments in this article. They also provide a very important link to his 2015 book chapter that is our focus in the last section of this article.)

Among the comments Peter makes about the nature of a Science For All are that it needs realistic objectives for students to find personal and social relevance in science. He sets out 10 features defining Science For All and there is clear recognition of the three social dimensions mentioned in his 1973 article discussed and reproduced above. He also itemises the 12 "umbrella topic fields" identified in a 1982 British Commonwealth Curriculum Workshop in Cyprus, at which Peter was present, as "a minimum core of content that *all* children should be given an opportunity to learn through science education in schooling" (1985, p. 429; emphasis in original). As the topic fields have a "socially useful focus for the learning outcomes, the content to be learned will be informed by (or based on) scientific knowledge rather than being just the scientific knowledge itself" (1985, p. 432).

Peter Fensham (1994) and an Important and Different Consideration of Progression in School Science

Some Introductory Thoughts About This Article

The core idea of "progression" in this article should not be confused with the soon-to-be emerging research focus on "learning progressions" and the similar, but more European-related, focus on Design Based Research. Peter's focus here is on considerations of progression in the *intended* curriculum (so, on progression in intentions), while learning progressions research considers data about the *attained* (or learned) curriculum (so, on progression in outcomes).

Peter's consideration of progression in the intended curriculum used the notion of Curriculum Emphases advanced by the late Doug Roberts (see Roberts, 1982), an idea that Peter found of great value for many years. (Peter and Doug remained in communication for decades.)

> A curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself ---objectives which provide answers to the student question: 'Why am I learning this?'"
> (Roberts, 1982, p. 245).

The beginnings of this article contain clear links back to Peter's 1985 Science For All article in his early comments about the first attempts being made just a few years before to conceptualise and define science education for all of the compulsory years, and to consider the curriculum as a whole (across all disciplines). Today, it seems odd to us that Peter does not reference his Science For All publication.

The reprinted article **(Fensham, 2022a)**

Further comment about this article

We see very important, and widely unrecognised, points in the article with Peter's comments on the emergence of matrices to layout the intended science curriculum, and his observation that at least some aspects of progression come from "process" being part of the considerations of the content of the curriculum for the compulsory years of science (that is, for Science For All students to this level). Most significant, in our opinion, is Peter's further elaboration that one consequence of the use of these matrices in conjunction with a primary focus on science content was to push content back down into the primary curriculum.

His arguments for the use of his construct of "Curriculum Opportunity for Science Education" and of the Roberts' construct of "Curriculum Emphases" as ways of rethinking progression from a form of 'big picture' approach are also significant, and we suggest insufficiently considered by others since the publication of this work. Indeed, we note that we can find no evidence of use of "Curriculum Opportunity for Science Education" again.

Peter's point near the conclusion of this article that "[t]his growing awareness of science and science learning is a very different type of progression from those suggested in the national curricula" is another significant observation. His argument that such a basis for progression would lead to student awareness of the purposes of the curriculum, and, in turn, define appropriate pedagogies, we conject has been fostered by the breadth of his engagements in the practice of science education.

His notion of the shift of broad curriculum focus from the 1960s to the 1990s as indicating a shift from "Induction into Science" to "Gaining Empowerment from Science" is, we believe, quite powerful and elegant in its simplicity of expression. More importantly, it forecasts this specific emphasis in much of his curriculum writing in this current century, including all three publications on which the final three sections of this article are focussed.

Peter Fensham (2000) and Further Considerations of the Content Appropriate for a Science For All

This chapter expands on the 1994 *RISE* article in terms of the consequences for choosing content when progression is viewed in terms of curriculum emphases. It is, among many other things, a very useful bridge between Peter's 1994 and 2016 *RISE* publications. In this chapter, he expands on choosing content (pp. 149–157), looking at a variety of approaches including drawing on the expertise of experts in science (e.g. Project 2061 from the American Association for the Advancement of Science, 1990) and/or science educators (e.g. the National Curriculum project in England and Wales, 1989), the "maintenance of essential science knowledge" (e.g. the approach adopted by TIMSS in choosing what was important to measure in terms of student learning), a focus on 'Coherence and linkage of science learning', practical science knowledge-in-action (Layton et al., 1994), higher order reasoning in science (the approach initially adopted by the OECD in their PISA project), and seeking projections about possible curriculum content in the future (a UK approach that eventually led to new science courses, including the rather different "21st Century Science").

Towards the end of the chapter, Peter argues the merits of approaches to choosing content that consider the "big picture" of Curriculum Emphases (and points out again the dramatic failure of the 1988 England and Wales initial National Curriculum with all its levels and attempts to define progression), and the very different content selection and appropriate pedagogical consequences that are derived from the much more learner-inclusive German perspectives of Didaktik and Bildung (see, for example, Fischler, 2011). He continued to consider both these perspectives, and particularly the constructs of Didaktik and Bildung, as positions that allowed more helpful approaches to considerations of all of the intended, implemented, and attained curriculum.

Peter Fensham (2016) and Considerations of the Future Curriculum in School Science

Some Introductory Thoughts About This Article

This reprint from *RISE* is more substantive and more wide ranging than the previous two we have included here. In part, of course, this reflects the continued development in Peter's thinking and engagement with scholars around the world. But it is also, to some extent, a consequence of the previous two *RISE* articles we have included being presentations at the annual ASERA conference (as were all *RISE* articles until the start of 1995).

An aspect of recent Australian curriculum history is important for consideration of this article. That "technology" emerged as a subject in its own right was a very important shaper of the school science curriculum through the 1990s across Australia (and in many other countries). In essence, in Australia, this came from the 1989 "Hobart Declaration", the first all-Ministers of Education (all State and Federal) statement of "Common and Agreed National Goals for Schooling in Australia" (and the beginnings of our eventual attempts at a national curriculum). This document gave these goals within the frame of "Eight Key Learning Areas". Two of these eight were "science" and "technology", each described at that time as "different ways of knowing", with "technology" being seen as "design, make, appraise". As well as the broad move from the Hobart Declaration to develop technology as a "different way of knowing" resulting in the bridging "T" in STS being taken out of science, and science content being pushed further down into primary schools, we believe two other points are important background and context for reading this 2016 article of Peter's: (i) "technology" was never intended to in any way be ICT, and initially it absolutely was not ever so described; and (ii) when later the notion of technology as a different way of knowing drifted out of our collective curriculum consciousness again, it did not move back into science to a sufficient extent so as to encourage a really serious regeneration of STS.

One aspect of Fig. 1 in this 2016 *RISE* article, a figure that we see as an excellent visual summary of many things, is that we see it as every bit as valuable and powerful as it was in the exact same form in the chapter Peter wrote for his 1988 edited volume *Development and Dilemmas in Science Education*, notwithstanding the shortcomings of the Figure as noted by Peter in the 2016 article. (In the foreword of the 1988 book, as editor, Peter summarises his chapter as "juxtapos[ing] the sense of importance school science education is now assuming with a realistic appraisal of what we have learnt in the twenty-five years since 1960 when it was also very much front stage" (p. *x*).)

The consideration of the problems arising from the Federation of Australia with regard to responsibilities is important. It is too little recognised, in our view, how much difference there has been, for example, in developing and having accepted and adopted a national curriculum in countries that are a "single jurisdiction" in terms of education responsibility and power (e.g. England, New Zealand, South Africa) as compared with federated systems (e.g. Australia, Canada, USA). More fundamentally, we (Australia) suffer a lack of connection between national priorities and curriculum because states are still entitled, at least to a non-trivial extent, to do what they will with national curriculum.

***The reprinted article* (Fensham, 2022c)**

Further comment about this article

The five points in Peter's conclusion are already widely agreed and have been very commonly argued for a long time (particularly #1-#3; see, for example, the seminal work of Michael Fullan *The New Meaning of Educational Change* in any one of its now 5 editions), and all five points remain utterly critical to begin to be adopted by the full spectrum of those with power and finances and for whom curriculum is their responsibility. To make this point quite bluntly, many wait (and wait, and wait) for somebody responsible for curriculum change to accept that implementation of a new curriculum is the *beginning* of the change, not the end of the change.

Peter Fensham (2015a) and His Final Grand Vision for the Future of School Science Education

During this journey through Peter's thinking and writing about science, we chose to follow a curriculum thread, looking at science curricula in different eras, and considering Peter's underpinning views about how curricula reflected the connections between science and society, why curricula were not successful as a "one size fits all", and how the frequent lack of investment in teacher preparation and lack of authentic assessment (among other things) precluded effective implementation of curriculum change. Our focus on curriculum, its content, and its approach to the representation of science has perhaps obscured Peter's underlying vision of what students might actually gain from learning about science (see, for example, Fensham & Rennie, 2013).

Since before he began his career in science education in 1967, Peter has clearly believed that science should be accessible to all students, but the *RISE* articles we chose to reproduce here have focused more on curriculum content than student outcomes. That is not to say that student outcomes were ignored in curriculum documents, just that they were rarely articulated. Fittingly, in a book devoted to "The future of learning in science: What's in it for the student?" (Corrigan et al., 2015), Peter set out his thoughts very clearly. In an incisive chapter (Fensham, 2015a), Peter built a powerful argument for science curricula to provide opportunities for students to explore the trustworthiness of science; an ability to be discerning and able to make judgements about scientific issues of relevance to them. Peter recapped how a vision of the student as a "mini-scientist", behaving as real scientists might in their own laboratories, permeated the science curriculum into the 1960s. During the 1970s, a re-emerging focus on discovery learning appeared in some of the alternative curricula for the middle years, and then the Science for All theme of the 1980s morphed into the need for scientific literacy in the 1990s. By 2000, the "science-informed citizen" was described as a curriculum outcome but still, underneath, persisted an image of the mini-scientist. After Doug Roberts' (2007) analysis of scientific literacy introduced the inward-focused Vision I that privileged the canonical concepts of science, and the more outward-looking Vision II that dealt with science experienced in everyday life, Peter included this perspective in his thinking about curriculum focus. Unlike some others, Peter understood that Roberts did not mean that these visions were mutually exclusive, but that Vision II invariably contained elements of Vision I, but not vice versa. An inherent impediment to curriculum change was that Vision I outcomes were far easier to assess than outcomes from Vision II, with the result that students gained little experience of science and its place in the social and cultural world. How could students gain the empowerment from science that Peter mentioned in his 1994 article reproduced above?

Peter believed that students should be able to develop an "informed" trust in science. He agreed with Stephen Norris (1985) that all students needed to learn an attitude of reflective scepticism about science; an ability to determine who might be trusted regarding claims to knowledge and know how to make judgements about credibility. While this ability requires some knowledge of disciplinary science content, it is far more powerful to be able to know what knowledge to use, than to know the knowledge itself. Peter decided to describe a person who had the appropriate knowledge to be discerning about science and make judgements about it as a "connoisseur of science". Ever humble, Peter attributed his thought to use the term "connoisseur" to an address by Isabelle Stengers in 2011. But it was Peter's 2015 chapter that provided the underpinning argument that curriculum opportunities be provided to enable students to develop from their learning of science "a basis for deciding how, and when, to place trust in science. They will become, not experts in science, but *connoisseurs of science*" (Fensham, 2015a, p. 57, original emphasis).

Declarations

Conflict of Interest The authors declare no competing interests.

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