Research list:

Akhtar, Z., & Steinle, V. (2013). Probing students' numerical misconceptions in school algebra. In V. Steinle, L. Ball & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow* (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia, pp. 36 – 43). Melbourne: MERGA. https://www.merga.net.au/Public/Public/Publications/Annual_Conference_Proceedings/2013_MERGA_CP.aspx (abstract)

Akhtar, Z. & Steinle, V. (2013). Letter as object misconception in junior secondary school algebra. In A. M. Lindmeier & A. Heinze (Eds.) *Proceedings of 37th Conference of the International Group for the Psychology of Mathematics Education*. (Vol. 5, p. 4) Kiel, Germany: PME. http://www.igpme.org/publications/current-proceedings/ (no abstract)

Akhtar, Z., & Steinle, V. (2017). The Prevalence of the 'letter as object' misconception in junior secondary students. In A. Downton, S. Livy & J. Hall (Eds.), *40 years on: We are still learning*! (Proceedings of the 40th Annual Conference of the Mathematics Education Research Group of Australasia, pp.77 – 84). Melbourne: MERGA. https://merga.net.au/Public/Publications/Annual_Conference_Proceedings/2017_MERGA_annual_conference_proceedings.aspx (abstract)

Baratta, W., Price, E., Stacey, K., Steinle, V., & Gvozdenko, E. (2010). Percentages: The effect of problem structure, number complexity and calculation format. In L. Sparrow, B. Kissane & C. Hurst (Eds.), *Shaping the future of mathematics education* (Proceedings of 33rd annual conference of the Mathematics Education Research Group of Australasia, pp. 61 – 68). Fremantle: MERGA. https://merga.net.au/Public/Publications/Annual_Conference_Proceedings/2010_MERGA_CP.aspx (abstract)

Barzel, B., & Holzapfel, L. (2017). Strukturen also Basis der Algebra. *Mathematik Lehren*, 202, 2–8

Guzman, M. A. (2014). *The smart test system: teachers' views about this formative assessment for mathematics.* [Master's thesis, University of Melbourne]. https://minerva-access.unimelb.edu.au/handle/11343/44090 (abstract)

McKee, S. J. (2017). *Using teacher capacity to measure improvement in key elements of teachers' mathematical pedagogical content knowledge*. [Doctoral thesis, University of Melbourne] https://minerva-access.unimelb.edu.au/handle/11343/123566 (abstract)

Price, B., Stacey, K., Steinle, V., Chick, H., & Gvozdenko, E. (2009). Getting SMART about Assessment for Learning. In D. Martin, T. Fitzpatrick, R. Hunting, D. Itter, C. Lenard, T. Mills & L. Milne (Eds.), *Proceedings of 2009 Annual Conference of the Mathematical Association of Victoria.* (pp. 174 – 181). MAV: Melbourne. https://minerva-access.unimelb.edu.au/handle/11343/247761 (abstract)

Price, B., Stacey, K. Steinle, V., Chick, H., Gvozdenko, E. (2011). Getting SMART About Assessment for Learning in 2011. *Reflections*, 36 (3), pp. 3 – 7. (abstract)

Price, B., Stacey, K., Steinle, V., Gvozdenko, E. (2013). SMART online assessments for teaching mathematics. *Mathematics Teaching* (Issue 235, pp. 10 – 15). (no abstract)

Price, B., Stacey, K., Steinle, V., & Gvozdenko, E. (2014). Using percentages to describe and calculate change. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Curriculum in focus: Research guided practice* (Proceedings of the 37th annual conference of the Mathematics Education Research Group of Australasia pp. 517 – 524). Sydney: MERGA. https://www.merga.net.au/Public/Public/Publications/Annual_Conference_Proceedings/2014_MERGA_CP.aspx (abstract)

Quenette, J. (2014). *Diagnostic testing and changes to teaching practice in Year 9 mathematics classes.* [Master's thesis, University of Melbourne]. https://minerva-access.unimelb.edu.au/handle/11343/43027 (abstract)

Rule, V. (2017). *A case study of the influence of diagnostic information on a teacher's planning for a Year 8 algebra lesson.* [Master's thesis, University of Melbourne]. https://minerva-access.unimelb.edu.au/handle/11343/213997 (abstract)

Stacey, K. (2013). Bringing research on students' understanding into the classroom through formative assessment. In V. Steinle, L. Ball & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow* (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia, pp. 13 – 20). Melbourne: MERGA. https://www.merga.net.au/Public/Public/Publications/Annual_Conference_Proceedings/2013_MERGA_CP.aspx (abstract)

Stacey, K., Price, B., & Steinle, V. (2012). Identifying stages in a learning hierarchy for use in formative assessment – the example of line graphs. In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.), *Mathematics education: Expanding horizons* (Proceedings of the 35th annual conference of Mathematics Education Group of Australasia, pp. 393 – 400). Adelaide: MERGA. https://merga.net.au/Public/Publications/Annual_Conference_Proceedings/2012_MERGA_CP.aspx (abstract)

Stacey, K., Price, B., Steinle, V., Chick, H., & Gvozdenko, E. (2009, Sept 28–Oct 1). *SMART Assessment for Learning.* [Conference presentation]. International Society for Design and Development in Education, Cairns, Australia. https://minerva-access.unimelb.edu.au/handle/11343/247762 (abstract)

Stacey, K., Steinle, V., Gvozdenko, E., & Price, B. (2013). SMART online formative assessments for teaching mathematics, *Curriculum & Leadership Journal*, Vol. 11, Issue 20. http://www.curriculum.edu.au/leader/smart_online_formative_assessments_for_teaching_ma,36822.html?issueID=12826 (abstract)

Stacey, K., Steinle, V., Price, B., & Gvozdenko, E. (2017). Fit in Algebra? Mach den smart-test. *MatheWelt* 202, pp. 1 – 16. Seelze, Germany: Friedrich Verlag GmbH. (Translators Judith Blomberg & Maike Abshagen).

Stacey K., Steinle V., Price B., & Gvozdenko, E. (2018). Specific Mathematics Assessments that Reveal Thinking: An Online Tool to Build Teachers' Diagnostic Competence and Support Teaching. In T. Leuders, K. Philipp, & J. Leuders (Eds.), *Diagnostic Competence of Mathematics Teachers. Mathematics Teacher Education,* Vol. 11, (pp. 241 – 261). Springer, Cham. https://doi.org/10.1007/978-3-319-66327-2_13 https://minerva-access.unimelb.edu.au/handle/11343/247768 (abstract)

Stacey, K., Steinle, V., Wu, M., Pierce, R., & Giri, J. (2010, 29 Nov–2 Dec). Evaluating automated processes for revealing students' mathematical thinking. Unpublished symposium presentation. Annual Conference of Australian Association of Research in Education, University of Melbourne, Melbourne. https://minerva-access.unimelb.edu.au/handle/11343/247766 (abstract)

Steinle, V., Gvozdenko, E., Price, B., Stacey, K., & Pierce, R. (2009). Investigating students' numerical misconceptions in algebra. In R. Hunter, B. Bicknell & T. Burgess (Eds.), *Crossing divides* (Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia, pp. 491 – 498). Wellington: MERGA. https://merga.net.au/Public/Publications/Annual_Conference_Proceedings/2009_MERGA_CP.aspx (abstract)

Steinle, V., & Stacey, K. (2012). Teachers' Views of using an on-line, formative assessment system for Mathematics. *Pre-proceedings. 12th International Congress on Mathematical Education Topic Study Group 33, July 2012*, (pp. 6721 – 6730). COEX, Seoul, Korea. https://minerva-access.unimelb.edu.au/handle/11343/247767 (abstract)

Abstracts:

Abstract of Akhtar, Z. & Steinle, V. (2013)
This study was designed to probe students' thinking about which numerical values can be assigned to algebraic letters. The data from students in Year 7 (n=533), Year 8 (n=377) and Year 9 (n=172) was analysed using response patterns. The data confirmed that each year contained students with two different misconceptions; *Different Letter means Different Number* and the *Empty Box* misconceptions. The findings provide support for the Steinle et al (2009) hypothesis that a previously identified response pattern is a subset of the *Empty Box* misconception.

Abstract of Akhtar, Z. & Steinle, V. (2017)
The study investigated students' thinking about the use of letters in algebra. Responses of over 1400 Australian secondary school students to a set of three algebra items were analysed to determine the prevalence of the 'letter as object' misconception. We estimate that 50% to 80% of Year 7 students bring this misconception to their initial learning of algebra. Over 50% of Year 8 students and over 40% of Year 9 students in the sample also selected responses consistent with this misconception.

Abstract of Baratta, W., Price, E., Stacey, K., Steinle, V., Gvozdenko, E. (2010)
This study reports how the difficulty of simple worded percentage problems is affected by the problem structure and the complexity of the numbers involved. We also investigate which methods students know. Results from 677 Year 8 and 9 students are reported. Overall, the results indicate that more attention needs to be given to this important topic. Simple unit fraction equivalents seem to be emphasised, at the expense of fundamental definition ("out of a hundred") and apparently

easy percentages such as 30%. The draft National Curriculum gives better guidance on the variation amongst percentage problems.

Abstract of Guzman, Maria Alejandra (2014)
Given the continuous challenge of improving the quality of students' learning of mathematics at the school level, and the consensus on the impact that teaching practices have on student learning, several countries have incorporated the development of assessments to directly influence teaching practices, known as formative assessments. However, this response has faced challenges, such as the need for more evidence about which particular formative assessment strategies may be beneficial for the learning of both students and teachers. Accordingly, this research is focused on providing evidence about teachers' opinions from their experience as users of a particular formative assessment, the 'Specific Mathematics Assessments that Reveal Thinking' also known as the Smart Test System, developed at The University of Melbourne. The research aims to answer three fundamental questions. First, how do teachers perceive the quality of the Smart Tests items and the diagnosis provided from the Smart Test System? Second, to what extent, and how, do teachers utilize the information provided by the Smart Test System to change their teaching? Thirdly, to what extent, and how, do teachers report on their learning from their use of the Smart Test System? A mixed methodology approach was utilized according to the research questions, and an on-line self-administered survey was used as the method of data collection. The findings suggest that a majority of teachers who participated in this study have had a positive experience as users of the Smart Test System. Along with reporting that the Smart Tests items and the diagnosis provided are of high quality, many teachers mention formative uses of the Smart Test System. These uses mainly correspond to adjusting their planning and differentiation of their practices according to students' needs. Almost all teachers in this study stated that they have learnt something from the Smart Test System. The findings of this study provide some understanding about how the Smart Test System fulfils its formative purposes. The results contribute to determining teachers' opinions about the scope and the ways that they use the Smart Test System to adjust their practices. The results also identify some challenges that could be attended to in order to maximize the potential benefit from the use of the Smart Test System, and which can be considered to develop further formative assessment initiatives.

Abstract of McKee, Sara Jane. (2017)
School systems world-wide are investing increasing resources in assessment of students. The challenge is to gain value for teachers from this process. This study examined how we can use a construct of teacher capacity to identify improvements in teachers' knowledge of Mathematics, their knowledge of the curriculum, their understanding of student's mathematical thinking, and their ability to design and implement effective mathematics instruction as a result of using online diagnostic assessments (SMART tests- Specific Mathematical Assessments that Reveal Thinking.) Two principal challenges were addressed in this study: the first concerns how to translate a theoretical construct of teacher capacity in ways that truly reflect the professionally informed judgement and disposition to act. The second challenge was to design and use measures that would show improvement of teacher capacity over time as a result of using SMART tests. This study used innovative approaches involving teacher self-reports that were supported by evidence derived from a content specific questionnaire, related to the four elements of teacher capacity identified previously. The research study was carried out in the researcher's school. 14 teachers used SMART tests over the course of one semester. All teachers showed improvement in teacher capacity as a result of implementing SMART tests, however improved teacher capacity was most evident amongst accomplished and expert teachers. The use of SMART tests also had a direct impact on teacher planning and informed classroom instruction. The study concludes with recommendations for future research in schools and in pre-service teacher education, utilising online diagnostic assessments of students. This study provides insight into what teacher capacity means in an educational setting, and how leaders in schools can effectively measure and improve teacher capacity in a school setting.

Abstract of Price, B., Stacey, K., Steinle, V., Chick, H., Gvozdenko, E. (2009)
"Specific Mathematics Assessments that Reveal Thinking" - or smart tests - provide teachers with a quick and easy way to conduct assessment for learning. Using the internet, students in years 7, 8, and 9 undertake a short test that is focussed strongly on a topic selected by their teacher. Students' stages of development are diagnosed, and sent to the teacher within minutes. Many tests have been produced and are now being trialled in 7 Victorian schools. Where available, on-line teaching resources are linked to each diagnosis, to guide teachers in moving students to the next stage. This project is sponsored by the Australian Research Council and Victoria's Department of Education and Early Childhood Development.

Abstract of Price, B., Stacey, K. Steinle, V., Chick, H., Gvozdenko, E. (2011)
"Specific Mathematics Assessments that Reveal Thinking" - or smart tests - provide teachers with a quick and easy way to conduct assessment for learning. Using the internet, students in years 7, 8, and 9 undertake a short test that is focussed

strongly on a topic selected by their teacher. Students' stages of development are diagnosed, and sent to the teacher within minutes. Many tests have been produced and are now being used in schools. Where available, on-line teaching resources are linked to each diagnosis, to guide teachers in moving students to the next stage. This project was sponsored by the Australian Research Council and Victoria's Department of Education and Early Childhood Development.

Abstract of Price, B., Stacey, K., Steinle, V., Gvozdenko, E. (2014)
This study reports on the use of formative, diagnostic online assessments for the topic percentages. Two new item formats (drag-drop and slider) are described. About one-third of the school students (Years 7 to 9) could, using a slider, estimate "80% more than" a given length, in contrast with over two-thirds who could estimate "90% of" a given length. While four-fifths of the school students could, using drag-drop cards, choose the 2-step calculation of a reduced price after a 35% discount, only one-third could choose the corresponding 1-step calculation.

Abstract of Quenette, Jacqueline (2014)
Teachers can use various means, including diagnostic tests, to determine their students' knowledge. It is of interest to know the ways in which teachers interpret and act upon such diagnostic information. The aim of this study was to examine the use of a particular diagnostic testing system by six teachers in Year 9 mathematics classrooms. The focus diagnostic system was the SMART system (Specific Mathematics Assessment that Reveal Thinking), which provides teachers with an online diagnostic test, diagnostic analysis and teaching advice. This study focused on the use of the SMART system in two topics, linear equations and linear graphs. The participant teachers were interviewed before each topic to ascertain the ways in which they gathered knowledge about student understanding, current and intended teaching practices, and how they met individual student's learning needs. On conclusion of each topic, participants completed a questionnaire and an interview to determine if any changes had been made. The teachers found the SMART system gave them some useful data on their students. The diagnostic analysis revealed gaps or misunderstandings in some students' knowledge, the teachers realised that they could no longer assume that all students had the requisite prior knowledge. Through this discovery, teaching practice changed in a number of ways. First, the teachers were able to decide on a better starting point for the particular topic. For example, if many students did not have the expected prior knowledge the teachers began the topic with earlier concepts. Second, teachers could identify groups of students with similar learning needs and these students could be provided with activities that supported their learning. Furthermore, for some teachers it changed their view of students' mathematical ability from, 'some students do not have the ability to learn maths' to, 'these students have gaps in their knowledge and if these gaps or misconceptions are addressed, they could progress to more complex concepts'. Most significantly, teachers reported becoming more prepared with appropriate materials for either individual students or groups of students. Hence the SMART system supported teachers to cater for individual student needs by highlighting the learning needs of students.

Abstract of Rule, V. (2017)
With the emergence of online testing, data about students' mathematical thinking is becoming more readily available to teachers in the form of diagnostic information. The availability of such data presents opportunities for teachers to use the data to inform their planning and teaching. The aim of this research was to investigate how diagnostic information, provided by an online system, impacted a teacher's lesson planning for one Year 8 algebra lesson. The online assessment used to provide the diagnostic information in this research was the 'Specific Mathematics Assessments that Reveal Thinking' (SMART) test. The SMART tests system includes individual student diagnoses and teaching advice consisting of potential student difficulties and how to address these. In this case study, the teaching advice impacted the Year 8 mathematics teacher's awareness of potential student misunderstandings and resulted in the teacher changing their lesson plan on solving linear equations with pronumerals on both sides of the equation. The changes made included an emphasis on the gathering of algebraic like terms for explanations of solving equations with pronumerals on both sides of the equal sign. While broad generalisations cannot be made from this single case study about teacher planning, the findings suggest there are opportunities to help teachers better understand the developmental stages associated with learning how to solve linear equations, and the potential difficulties students may encounter. This study also allows for future research to be conducted on a larger scale about the impact of diagnostic information on teacher lesson planning.

Abstract of Stacey, K. (2013)
'Specific Mathematics Assessments that Reveal Thinking' (abbreviated as 'smart tests') provide on-line formative assessment of middle years students. They aim to put information from research on students' understanding directly into the hands of teachers, by providing quick automated diagnosis of learning for all students in a class. The Reflections test is used as an example to describe item presentation, evidence identification, and reporting to teachers, and highlight how pedagogical content knowledge can be built.

Abstract of Stacey, K. Price, B., Steinle, V (2012)
This paper discusses issues arising in the design of questions to use in an on-line computer-based formative assessment system, focusing on how best to identify the stages of a learning hierarchy for reporting to teachers. Data from several hundred students is used to illustrate how design decisions have been made for a test on interpreting line graphs.

Abstract of Stacey, K., Price, B., Steinle, V., Chick, H., & Gvozdenko, E. (2009, Sept 28–Oct 1)
"Specific Mathematics Assessments that Reveal Thinking," which we abbreviate to "smart tests," provide teachers with a quick and easy way to conduct assessment for learning. Using the internet, students in Years 7, 8, and 9 undertake a short test that is focused strongly on a topic selected by their teacher. Students' stages of development are diagnosed and sent to the teacher immediately. Where available, on-line teaching resources are linked to each diagnosis, to guide teachers in moving students to the next stage. Many smart tests are now being trialled in schools and their impact on students' and teachers' learning is being evaluated. Design issues are discussed.

Abstract of Stacey, K., Steinle, V., Gvozdenko, E., & Price, B. (2013)
In classrooms today it is expected that a student's learning program will be planned with their current level of understanding in mind. This is particularly demanding in the case of the mathematics curriculum, with its focus on developing increasingly sophisticated and refined mathematical understanding, fluency, logical reasoning, analytical thought and problem-solving. It is with all of this in mind that '*smart* tests' have been developed for use in year 5 to year 9 maths classes. A *smart* test is a *specific mathematics assessment that reveals thinking*. This assessment tool has been designed to give teachers information about the understanding of their individual students in key mathematics topics. These *smart* tests supplement, rather than replace, other forms of assessment. The most transformative use of *smart* tests in schools has occurred when they have been used to provide data on student understanding to a team of teachers working on curriculum improvement in their school. *Smart* tests can also be very helpful to professional learning teams with a focus on mathematics education and formative assessment.

Abstract of Stacey K., Steinle V., Price B., & Gvozdenko, E. (2018)
In this chapter, we describe the design of an online system for the formative assessment of students' understanding of mathematics and discuss how it develops diagnostic competence and influences teaching. The smart-test system covers many mathematics topics studied by students between about 10 and 16 years of age. It is programmed to provide teachers with an automated diagnosis of their own students' stages of development in specific topics and to report on an individual's errors and misconceptions, in order to inform teaching. Our claim is that teachers' diagnostic competence increases when they have easy access to information about their own students' thinking. In turn, this can further improve teaching, and hence learning. By drawing together evaluative data from four sources, we highlight aspects of teachers' initial responses to formative assessment and the effect of using this system on their knowledge for teaching and the subsequent changes to teaching practice. Overall, teachers report that using the smart-tests has improved their knowledge of the thinking of individual students as well as of students in general (i.e., their pedagogical content knowledge), and that they can use this information in several ways to adjust their teaching. Paradoxically, using smart-tests reduces the demand for teachers to have specific knowledge for diagnosis and at the same time increases this knowledge and so improves their diagnostic competence.

Abstract of Stacey, K., Steinle, V., Wu, M., Pierce, R., & Giri, J. (2010, 29 Nov–2 Dec)
Understanding student thinking is key to planning effective teaching. Research over three decades has established good knowledge of stages of development and common misunderstandings in many school topics. However, in order for teachers to make formative assessment a normal part of their practice, mapping of student understanding needs to be available for a greater proportion of the school curriculum. Online testing of students is beginning to create substantial databases which could provide relevant information. The aim of this symposium is to present and discuss methods which move towards automation of data analysis.

Abstract of Steinle, V., Gvozdenko, E., Price, B., Stacey, K., Pierce, R. (2009)
Details are provided of simple algebraic items which can be used to detect two particular ways students think about the numerical meanings of letters (in contrast to non-numerical thinking). The data from Year 7 students (n=228) and Year 8 students (n=139) on these items is analysed using response patterns to probe student thinking. Less than 10% of the students were correct on these items whilst the prevalence of the two most common error patterns is 20%-30% at each year level. New response patterns are detected, indicating that further improvements to the items will enable students' thinking to be investigated further.

Abstract of Steinle, V. & Stacey, K. (2012)
In this paper we discuss some issues arising from teachers' use of an on-line system for formative assessment of their

students' understanding of mathematics. The 'smart tests' cover many topics in secondary school mathematics, and are programmed to provide an automated diagnosis of students' stages of learning in specific topics, to inform teaching. In particular, we highlight teachers' views about: the desirability of formative assessment; the use that they make of this information; the provision of feedback; and the effect of using the system on their pedagogical content knowledge and subsequent changes to their practice .Overall, teachers report that use of the tests improves their knowledge of the achievement of individual students and students in general, and that they can use this information in several ways to improve their teaching.