Science, ICT and mathematics as curriculum priorities in primary schools: What are the practices and needs of beginning teachers?

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Abstract

This study was formulated within the context of an increasing recognition nationally of science, technology and mathematics education as curriculum priorities in primary schools. Recent graduates of a pre-service primary education program that had an emphasis on innovation and 'best practice' in science, ICT and mathematics education were surveyed to ascertain their teaching practices in science, ICT and mathematics, and their professional development needs within these three learning areas. Graduates within their first four years of teaching were asked to complete a written response, short answer questionnaire focused on: regularly used teaching practices, curriculum planning influences, professional development endeavours, formal or informal curriculum leadership roles or influences, and views of professional development needs. The responses (N=55) indicated: individual and class student learning needs and achievement levels, along with guiding curriculum documents were a major influence on curriculum planning and teaching practices; lack of appropriate resources impacted upon teaching particularly for ICT and science; science was receiving relatively little attention within overall school curricula and teachers had received little or no professional development in science; and resources and personalised professional development and support were seen as the greatest needs in efforts to enhance science, ICT and mathematics teaching.

Introduction

The larger study in which the findings reported in this paper were situated was conceptualised within an increased emphasis in Australia recently on the enhancement of science, technology, and mathematics teaching and learning. Various national initiatives through government funding schemes have included: expansion of *Questacon-Smart Moves*, a science, engineering and technology program targeting rural and regional secondary schools; *Science Connections*, a program to raise awareness of science and related developments and innovations; the *National Primary School Science and Literacy Project,* a program developed by the Australian Academy of Science; and the *Australian Government Quality Teaching Programme*, a program to improve teachers' skills and understandings in priority areas including science (Australian School Innovation in Science, Technology and Mathematics (ASISTM), n.d.). More recently, establishment of the *National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia* (SiMERR), and commencement of the *Australian School Innovation in Science, Technology and Mathematics* (ASISTM) Project have provided funding to support "real and permanent improvements to the ways in which science, technology and mathematics are taught in our schools" (ASISTM, n.d.).

At a more local level, various state and territory initiatives have also contributed to enhancing science, technology and/or mathematics teaching and learning. For example, within Western Australia (WA), where this study was conducted, government schools have received funding and teacher professional development opportunities in mathematics and in technology through the *Getting it Right – Literacy and Numeracy Strategy* (GIR, n.d.) and the *100 Schools Project* (now called the *Learning with ICT Project*) (n.d.). Mathematics and technology have also been targeted in the ongoing professional development programs of the Catholic Education Office Western Australia (CEO, n.d.) and the Association of Independent Schools of Western Australia (AISWA, n.d.).

It was within this context of science, ICT, and mathematics as curriculum priorities that this study was formulated. Recent graduates of the Bachelor of Education (Primary Education) and Bachelor of Education (Early Childhood Education) degrees at Curtin University had received in their studies strong emphases on ICT and mathematics, although there had been a much lesser emphasis on science. The researchers wished to find out what these recent graduates were doing in their teaching of science, ICT, and mathematics. More specifically, three research questions framed the design of the research study:

1. What are the employment demographics of our recent graduates; specifically, school locations, year levels taught and employer?
2. How are these graduates teaching mathematics, ICT and science?
3. What do these graduates want to develop further their teaching of mathematics, ICT and science?

This paper reports on the findings from the second and third research questions. The significance of this research within the context of the ongoing Bachelor of Education (B.Ed.) program evaluations and revisions was that findings would provide details of the impact of the programs on graduates' teaching practices subsequent to their initial education at the university. For example, if their reports of teaching practices did not reflect the innovative and effective 'best practice' mathematics, ICT and science teaching they learned about in their B.Ed. programs, then the nature and content of those programs would need to be examined. Similarly, their reports of how they want to further develop their teaching in mathematics, ICT and science could provide insight into how to revise the B.Ed. programs to better support both their teaching practices and ongoing professional learning after graduation.

Research Context

The Bachelor of Education (Primary Education) and Bachelor of Education (Early Childhood Education) programs at Curtin University are 4-year pre-service teacher education courses. The Early Childhood teacher education program focuses on Kindergarten to Year 3 students in Western Australian schools (4-8 year olds), while the Primary teacher education program focuses on Years 1 to 7 (6-12 year olds). Both programs include studies in the development of broad professional knowledge and skills in planning, teaching and assessing, including 20 weeks of school practicum. Both also include specific studies in the eight learning areas of the Western Australian *Curriculum Framework* (Curriculum Council of Western Australia, 1998): the Arts, English, Health and Physical Education, Languages Other Than English (LOTE), Mathematics, Science, Society and Environment, and Technology and Enterprise.

In addition, recent graduates completed their degrees entirely within the context of the overall guiding curriculum document for WA, the *Curriculum Framework for Kindergarten to Year 12 in Western Australia* (Curriculum Council of Western Australia, 1998). The WA *Curriculum Framework* is based upon student learning outcomes as the focus for planning and assessment, and as a consequence it emphasises that planning, teaching and assessment need to be in the context of student prior knowledge and skills, student learning needs, and the ongoing monitoring of the progress of student learning. This framework is in contrast to a perception that curriculum can be pre-determined, the same for all students in content and pace, and relatively independent of context, be that rural, urban or otherwise.

An additional aim of the B.Ed. programs is to prepare teachers who have the content knowledge, pedagogical competence, and professional confidence to implement innovative and effective teaching and learning practices, and ultimately to become curriculum leaders. The programs are built around a learner-focused curriculum designed to develop teachers who are professionally competent in knowledge and skills, while also being life-long learners who, via critical reflection, will actively examine, think about and continually endeavour to improve their teaching practices. In the area of Information and Communication Technologies (ICT), students are exposed to the most recent technology developments in related educational practices, so it was particularly relevant that this research study identify whether recent graduates were implementing the newest developments.

Method

The research was a survey study using a written response, short answer questionnaire (see Appendix A). The questionnaire, in addition to gathering demographic data on the graduates' employment history since graduation, was designed to identify in each of the areas of mathematics, ICT and science: regularly used teaching practices; curriculum planning influences; professional development endeavours; formal or informal leaderships roles or influences; and views of professional development needs. This paper reports on the methods and resources being employed by teachers, factors influencing their planning, and teachers' perceived needs for further professional development. The paper aims to describe key findings, rather than attempting to give definitive reasons or explanations for the findings.

Questionnaire design

Research Question 3 was straightforward in that it was explicitly addressed by asking the respondents to give details of their professional development activities completed, and specific support they wanted to further develop their teaching. To establish content validity, research Question 2 (i.e. how graduates are teaching) required input from the B.Ed. teaching staff to identify what specific teaching strategies or resources would be reasonable to include on a checklist. In addition, research Question 2 required input from teaching staff to identify key features within each of mathematics, ICT and science that would take into consideration the context of these learning areas within schools. For example, it would be common in primary schools in WA to have a designated 'mathematics coordinator', but it would not be common to have a 'science coordinator', and hence the questionnaire specifically asked about playing a professional role as a mathematics coordinator. Similarly, since ICT and science are often taught via integration with other aspects of the curriculum, but mathematics is predominantly taught as a discrete subject, the questionnaire asked about integration for ICT and science but not for mathematics.

To further enhance the content validity of the questionnaire, once a draft was completed, teaching staff within each of the areas of mathematics, ICT and science were asked to provide feedback on the questionnaire's content and the wording of questions, particularly with regard to what they deemed to be relevant aspects of the respective learning area curriculum in the B.Ed. programs that had not been included in the draft. Next, to provide feedback on the clarity of questions and the readability of the presentation, the questionnaire was trialed with a sample of 45 final year B.Ed. students. Minor revisions in wording and layout were then completed. A covering letter was also prepared to inform the graduates of the purpose of the questionnaire and the ethical aspects of the conduct of the research (e.g., that anonymity would be maintained and the return of a completed questionnaire would serve as consent to participate).

Research sample

Initially 300 surveys were mailed out in May 2006 to all graduates from 2002 to 2005. Mailing addresses were obtained from the university's student data base, which was known to be a problematic information source because unless graduates had personally contacted the university to update their contact information the information available would be the addresses used during the students' final year of enrolment at the university. Thus, it was not surprising that within a few days of the mail-out, over 50 envelopes were returned, with no person by the name on the envelope at that address. It is not known how many additional envelopes were sent to an invalid address but not returned by a current occupant at that address, but it is likely it was at least 50 more. There were a few cases in which an envelope was received by a parent who then telephoned to say the intended recipient was currently overseas, travelling, or otherwise not easily accessible. The final number of returned completed questionnaires was 55, which consisted of 6 forms from 2002 graduates, 17 from 2003, 15 from 2004 and 17 from 2005.

Findings and Discussion

In analysing and reporting on data for Research Questions 1 and 2, a distinction was made between graduates currently teaching in metropolitan versus non-metropolitan schools. However, the discussion here does not always focus upon this distinction because it did not always identify relevant differences. The reason for making the distinction was that metropolitan versus non-metropolitan locations often differ regarding availability of resources.

Research Question 2: How graduates are teaching mathematics, ICT, and science

Time allocation for mathematics, ICT and science teaching

The data in Table 1 indicate that a more time is allocated to mathematics than ICT or science, and on average this time is more than double that of the other two subjects. This finding confirms what is generally taken as 'given' knowledge about schools; specifically, that mathematics is taught regularly, while science often is taught only once a week. What is unclear from the ICT data is the degree to which time spent teaching ICT is for ICT as a learning area on its own, and/or as tool for learning in other subject areas. Most of the graduates (N = 40) indicated they taught ICT integrated with other learning, and 17 of these 40 indicated they also devoted time to the specific teaching of ICT skills. An additional 6 of the sample of 55 stated ICT was taught as a discrete subject, either by a specialist, or at a particular time each week within a computer lab. Examples related to integration included: using computer software programs or internet sites for skill practice within mathematics or English, using the internet as an information resource, and using programs such as Word or PowerPoint as communication and presentation tools.

Table 1
Weekly hours spent teaching mathematics, ICT, and science

Location	Maths (N=49)		ICT (N=23)		Science (N=43)	
	Range	Average	Range	Average	Range	Average
Metropolitan	2.5 - 7.0	4.5	1 – 3.5	1.8	0 – 4.5	1.6
Non-Metropolitan	1 -10	4.7	0.5 – 4.0	1.9	0.5–3.5	1.5

Notes:
For mathematics, time range includes graduates working in high schools.
For science, three graduates rely on a specialist science teacher.
N < 52 because some graduates left the question blank, and for ICT they sometimes merely stated 'daily'.

Teaching methods and resources

In Tables 2 and 3, a teaching method has been categorised as a 'learner-focused' or 'teacher directed' method according to the degree to which it involves students in making meanings for themselves in comparison to demonstrating previously learned knowledge or practising teacher-given procedures. It is acknowledged that this distinction has limitations; for example, a blackline master might be an outline of an investigation or an open-ended task, or the use of concrete materials might be in a rote-learned procedural context. However, the categorisations were made according to common usage of the methods. What is most noteworthy about the use of these distinctions is that the data indicate the graduates were using a range of teaching methods in mathematics and science. In particular, many methods they used regularly could be said to be in concordance with constructivist learning theory and an outcomes focused approach to teaching, key aspects of their B.Ed. programs.

Table 2
Methods and resources for teaching mathematics used regularly by graduates

Method or Resource		**All graduates** (N=52)
Learner-focused methods	Concrete materials	49 (94%)
	Whole class discussion	49 (94%)
	Small group work	43 (83%)
	Co-operative work	38 (73%)
	Open-ended tasks	35 (67%)
	Investigations	21 (40%)
Teacher-directed methods	Teacher demonstration	47 (90%)
	Whiteboard work	36 (69%)
	Blackline masters	17 (33%)

	Student workbooks	12 (23%)
	Mental maths tests	10 (19%)
Teacher resources	Teacher textbook	24 (46%)
	Resource books/journals	18 (35%)
Usage unclear	Computer software	13 (25%)
	Internet	6 (12%)

Table 3
Methods and resources for teaching science used regularly by graduates

Method or Resource		**All graduates** (N=52)
Learner-focused	Concrete materials	42 (81%)
	Pupil-led investigation	23 (44%)
Teacher-directed	Teacher demonstration	39 (75%)
	Student workbooks/sheets	13 (25%)
Usage unclear	Teacher-led investigation	39 (75%)
	ICT	9 (17%)
	Internet	9 (17%)

Since the items in Table 4 refer to *which* resources graduates use, rather then *how* they use them, it was not possible to distinguish these resources as learner- or teacher-focused. However, the data in Table 4 do provide evidence that graduates are making use of technology in their classrooms on a regular basis.

Table 4
Resources for teaching ICT used regularly by graduates

Resource	**All graduates** (N=52)
PCs in classroom	38 (73%)
Digital cameras	37 (71%)
Internet	36 (69%)
Computer lab	25 (48%)
Email	25 (48%)
Intranet	23 (44%)
CD Rom/Software	22 (42%)
Laptops	16 (31%)
Interactive whiteboard	6 (12%)

Influences upon curriculum planning

From tables 5, 6 and 7 it can be seen that the most prominent factors across all three of the subject areas (mathematics, science and ICT) that guided the teachers' decisions in curriculum planning were 'student needs/achievement' and 'curriculum documents'. This finding is consistent with the focus of the graduates' university courses in that their B.Ed. programs were based upon using the WA *Curriculum Framework* (Curriculum Council, 1998) as a guiding document to flexibly plan for and assess teaching and learning activities. Mores specifically, the *Curriculum Framework* uses a learning outcomes focus for curriculum planning and assessment, by which diverse achievement levels, learning needs, and ongoing progress are explicitly recognised.

Tables 5, 6, and 7 identify distinct differences between the three subject areas with regard to 'First Steps Maths' and 'Getting it Right' (Mathematics), 'Infrastructure' and 'Cross-curricular integration' (ICT), and 'School specialist' and 'Thematic integration' (Science). 'First Steps Maths' and 'Getting it Right' are unique to the mathematics learning area in that they are programs created specifically for mathematics. It appears from the data that they have had an impact on classroom teaching. For ICT, the emergence of 'Infrastructure' as a key influence is not surprising, particularly since it is noted also that 'Resources' were not always distinguished from 'Infrastructure'. ICT within teaching is reliant on the availability and reliability of hardware and related resources such as computer, printers, and internet connections. The emergence of 'Cross-curricular integration' and 'Thematic integration' within ICT and science, respectively, indicate that these forms of curriculum integration have been adopted by the graduates to a certain extent. 'Integration' was a focus within these learning areas within the graduates' B.Ed. programs, although it cannot be claimed from this survey that a direct link exists between their B.Ed. programs and current teaching practices. Finally, it is noted that, although not widespread, it is only within science that there was mention of a specialist teacher. These differences, although not generalisable to the larger population of beginning teachers, could be said to reflect possible current trends within each of the three subject areas.

The 'School' influence merits further examination in that it emerged as a relatively prominent influence for mathematics and science but not ICT. Further, for all three of mathematics, ICT and science it was a stronger influence for metropolitan schools than non-metropolitan schools, and for both ICT and science was not mentioned at all by graduates from non-metropolitan schools. The short-answer responses made on the questionnaire concerning the 'School' influence often related to school-wide plans. Hence, one might speculate that in non-metropolitan schools, which are generally smaller in size than metropolitan schools, teachers have more individual control over curriculum content.

Table 5
What guides choices when planning mathematics teaching

Influence	**All graduates** (N=52)	**Metropolitan schools** (N=34)	**Non-Metropolitan schools** (N=18)
'First Steps' Maths	16 (31%)	8 (24%)	8 (44%)
'Getting it Right'	7 (13%)	3 (9%)	4 (22%)

Student needs/ achievement	36 (69%)	25 (74%)	11 (61%)
School	15 (29%)	11 (32%)	4 (22%)
Curriculum documents	14 (27%)	7 (21%)	7 (39%)
Other	28 (54%)	17 (50%)	9 (50%)

Notes:
'Other' includes: resources (equipment, TAs, books, journals), mathematics learning theory, personal philosophy, theme integration, use of ICT, specific mathematics programs, time, numeracy net
'Resources' can have a positive or negative influence

Table 6
What guides choices when planning ICT teaching

Influence	**All graduates** (N=52)	**Metropolitan schools** (N=34)	**Non-Metropolitan schools** (N=18)
Infrastructure	14 (27%)	9 (26%)	5 (28%)
Resources	13 (25%)	11 (32%)	2 (11%)
Student needs/ achievement	16 (31%)	10 (29%)	5 (28%)
School	3 (6%)	3 (9%)	0 (0%)
Curriculum documents	3 (6%)	1 (3%)	2 (11%)
Cross-curricular integration	10 (19%)	8 (24%)	2 (11%)
Other	18 (35%)	13 (62%)	5 (39%)

Notes:
'Other' includes: time, teacher's ability, ease of use.
It is hard to distinguish between infrastructure & resources; resources can have a positive or negative influence

Table 7
What guides choices when planning science teaching

Influence	All graduates (N=52)	Metropolitan schools (N=34)	Non-Metropolitan schools (N=18)
Specialist teacher	4 (8%)	1 (3%)	3 (17%)
Resources	9 (17%)	5 (15%)	5 (28%)
Student needs/ achievement	16 (31%)	11 (32%)	5 (28%)
School	12 (23%)	12 (35%)	0 (0%)
Curriculum documents	19 (37%)	11 (32%)	8 (44%)
Thematic curricular integration	23 (44%)	17 (50%)	5 (28%)
Other	8 (15%)	5 (15%)	3 (17%)

Notes:
'Other' relates mostly to time.
'Resources' include: publications (e.g. ENGQuest, Primary Investigations).
'Resources' can have a positive or negative influence

Research Question 3: Graduates' needs to develop their mathematics, ICT and science teaching

According to Table 8, for all three of mathematics, ICT and science, graduates identified professional development, resources, and professional support or mentorship as the main things needed to support the development of their teaching.

The proportions for all three of these factors were higher for metropolitan than for non-metropolitan locations, which is noteworthy because a general perception within the education community is that metropolitan teachers and schools have more extensive access to resources and professional development. Thus, this is a facet of the findings that indicates further research is needed regarding these factors.

Table 8
Support required to develop mathematics, ICT and science teaching

Subject	Mathematics		ICT		Science	
Location	M (N=34)	NM (N=18)	M (N=34)	NM (N=18)	M (N=34)	NM (N=18)
Professional development	16 (47%)	7 (39%)	17 (50%)	8 (44%)	14 (41%)	5 (28%)
Resources	9 (26%)	3 (17%)	18 (53%)	7 (39%)	14 (41%)	4 (22%)
Support/mentorship	11 (32%)	5 (28%)	5 (15%)	1 (6%)	4 (12%)	1 (6%)
Time	1 (3%)	3 (17%)	1 (3%)	1 (6%)	2 (6%)	3 (17%)
Other	5 (15%)	6 (33%)	5 (15%)	3 (17%)	4 (12%)	1 (6%)

No response	5 (15%)	2 (11%)	4 (12%)	4 (22%)	5 (15%)	8 (44%)

M = Metropolitan; **NM** = Non-Metropolitan

Conclusions and Implications

It is acknowledged that the findings from this small-scale survey study are not conclusive with regard to the teaching practices of teacher education graduates in WA in their first few years of employment. However, the findings do point to avenues for further investigation.

In summary, the findings indicate:

- There is consistency between metropolitan and non-metropolitan schools with regard to weekly time allocation for teaching mathematics, ICT and science. The data also confirm commonly held beliefs that mathematics is taught regularly, while science is often only taught once a week.
- There was a strong degree of similarity between the methods and resources used in metropolitan and non-metropolitan schools. Teachers in both contexts are using a range of teaching methods in mathematics and science, and many of the methods regularly used reflect the focus placed on outcomes and constructivist learning theory in their B.Ed. programs.
- Teachers are making regular use of technology in their classrooms.
- Major factors guiding teachers' decisions in curriculum planning were the needs of their students and the WA *Curriculum Framework.*
- Programs specifically created for mathematics teaching, such as *First Steps Maths* and *Getting it Right* have had an impact on classroom teaching.
- Graduates have adopted forms of curriculum integration to some extent, possibly reflecting the emphasis placed on this in their B.Ed. programs.
- 'School' emerged as a relatively prominent influence on teachers' curriculum planning for mathematics and science, but not for ICT. It was also a stronger influence for metropolitan schools than non-metropolitan schools with regard to all three learning areas.
- Across all three learning areas, teachers identified professional development, resources and professional support or mentoring as the main things needed to support the development of their teaching. Interestingly, the proportions for all three of these factors were higher for metropolitan than non-metropolitan locations. This finding challenges the common perception that metropolitan teachers and schools are advantaged in their access to professional development opportunities and teaching resources.

The main implications of these findings relate to the following points:

- The findings regarding time allocated to the three learning areas suggest that greater emphasis and value need to be placed on the teaching of science. Further research on the causes of the neglect of science teaching in the classroom needs to be conducted to provide a better understanding of why this is occurring and how it can be addressed.
- Technology is playing an increasingly critical role in the classroom. Schools and teachers need to be aware of how it can best be utilised for teaching purposes.
- Further research is required to more conclusively investigate this study's findings regarding access to professional development, and the apparent differences between metropolitan and non-metropolitan locations.

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Appendix A - Curtin University Bachelor of Education Graduate Teachers Mathematics, ICT and Science Survey
(Condensed format; content only, without format and boxes to be ticked))

Section A: Teacher Profile

1. What is your current age? Under 25 / 25-30 / 31-35 / 36-40 / Over 40

2. What is your sex? Male/Female

3. Which school system do you currently teach in?
Government / Catholic / Independent / Not currently teaching

4. Which year did you complete your BEd studies? 2005 / 2004 / 2003 / 2002

5. Please give details of where you have been teaching since graduation
(Note: The names of schools will not be identified in any reports from this survey. They will only be used to determine general geographical locations of graduates.)

Name of School	Year Group(s) taught	Dates of Employment

Section B: Your Mathematics teaching

1. On average, how many hours do you teach Mathematics each week?

2. Which of the following do you use regularly (i.e. at least once a week) as part of your Maths program? (tick all that apply)

Student workbooks / Teacher textbook / Computer software / Internet / Concrete materials / Blackline masters / Resource books or journals / Whole class discussion / Mental maths tests /
Small group work / Co-operative work / Whiteboard work / Teacher demonstration / Investigations / Open-ended tasks / Other-Please specify______________________

3. Please explain what guides your choices when planning your Maths program.

4. Are you a Mathematics Coordinator? Yes/No

5. Please explain any influence you have on the teaching of mathematics in your school.

6.What Mathematics professional development opportunities have you participated in since you graduated?
- in school
- out of school

7. Please explain how satisfied you are with your Mathematics teaching.

8. Comment on what would support the development of your Mathematics teaching?

Section C: Your Information & Communication Technology (ICT) teaching

1. On average, how often do you use ICT in your classroom each week?

2. Which teaching tools/resources do you use regularly (i.e. at least once a week)? (tick all that apply)

A computer lab / PCs within your classroom / Laptops / Interactive whiteboard (SMARTBoard) /
Internet / School Intranet / E mail / CDRom or Software / Digital cameras /
Other-Please specify______________________

3. Please explain what guides your choices when planning your ICT program.

4. Do you teach ICT as a discrete subject, integrate it into other programs or both? Please give some examples.

5. Please explain any influence you have on the teaching of ICT in your school.

6.What ICT professional development opportunities have you participated in since you graduated?

- in school
- out of school

7. Please explain how satisfied you are with your ICT teaching and the resources that are available to you, noting if there have been changes in this regard since you graduated.

8. Comment on what would support the development of your ICT teaching.

Section D: Your Science teaching

1. On average, how many hours do you teach Science each week?

2. Which teaching methods/resources do you use as part of your Science program? (tick all that apply)

Teacher demonstration / Teacher-led investigation / Pupil-led investigation /
Student workbooks or sheets / Concrete materials / ICT / Internet /
Other-Please specify______________________________

3. Please explain what guides your choices when planning your Science program.

4. Do you teach Science as a discrete subject, integrate it into other programs or both? Please give some examples.

5. Please explain any influence you have on the teaching of Science in your school.

6.What Science professional development opportunities have you participated in since you graduated?

- in school
- out of school

7. Please explain how satisfied you are with your Science teaching.

8. Comment on what would support the development of your Science teaching.