Teaching problem solving in technology rich environments

Needs analysis research report

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Teachers' Beliefs

One of the aims of the *Needs Analysis* was to investigate teachers' beliefs about problem solving in mathematics. In order to do this, it was decided to interview a sample of four teachers in each country. A range of participants in terms of gender, years of experience, and level of teaching (primary, secondary, adult and vocational education) were recruited and each asked the following six questions:

1. What is problem solving? How would you define it?
2. How/why is problem solving important in mathematics?
3. What are the barriers to effective problem solving in the mathematics classroom?
4. What supports are there for effective problem solving in the mathematics classroom?
5. What role can / does technology in promoting problem solving in the mathematics classroom?
6. How could problem posing amongst students be promoted more?

Their answers are summarised below.

What is problem solving? And how would you define it?

In defining problem solving, two themes which arose in the four countries were real life applications, and students being required to think deeply, and extract relevant information in order to tackle the problem. In the Finnish interviews, a problem's relevance to real-life had to do with practical or professional concerns, while in Denmark and Scotland, the teachers emphasised relevance to the students' own everyday experience: problem-solving as a "life skill".

Regarding the process of problem solving, in Northern Ireland the teachers emphasised that problem-solving requires students to think and reflect. This was mirrored in the Scottish interviews, which demonstrated opinions that the mathematical challenge must be embedded in the text and extracted by the learners. The Danish teachers made a similar point also. Equally, in Finland, one teacher mentioned using knowledge in new ways, and another mentioned problem solving as a creative mathematical activity.

Certain anomalies should also be noted. Firstly, in the Danish interview data some teachers indicated beliefs that students should be taught procedurally before tackling difficult problems. Furthermore, the Scottish cohort of teachers noted the importance of mindset and confidence regarding problem-solving.

How/why is problem solving important in mathematics?

In keeping with the teachers' definitions of problem solving, in all four countries, problem solving was deemed particularly important regarding the future everyday lives of their students.

This was described in terms of improving the students' skill base and developing their ability to apply mathematics in professional settings. In Northern Ireland, there was also a mention of problem-solving's importance in developing resilience and "stickability" for students tackling difficult issues.

A member of the Scottish cohort also mentioned that problem solving is important because it helps students to develop independent thought, and thus to become functional members of society.

What are the barriers to effective problem solving in the mathematics classroom?

In Denmark, Scotland, and Northern Ireland, student attitudes or beliefs were specifically mentioned as a barrier to effective problem solving in an educational setting. These attitudes consisted of lower confidence, fear and anxiety, and a tendency to give up too quickly. (Failing to persevere was also mentioned briefly by the Finnish teachers).

Prescriptive, traditional teaching methods and school structures were also identified as barriers in Denmark, Scotland, and Northern Ireland. It was pointed out that oftentimes teachers are too inclined to lead and guide their students, and that mathematics is often taught in a prescriptive manner, with focus on repetition. The lack of student autonomy which comes from such methods can cause issues.

In Finland, particular emphasis was placed on time – the implication being that modern problem-solving methods are time consuming and thus difficult to implement in a school setting. These teachers were also of the belief that often students' basic mathematical skill set is too low for effective problem solving, and that the language of mathematical problem solving caused major difficulties for students.

What supports are there for effective problem solving in the mathematics classroom?

There was a significant amount of variety in the suggested supports for effective problem-solving across the countries. One common aid mentioned was that of teamwork – students being able to work together to discuss their preferred methods, and to share knowledge and understanding. In Northern Ireland, teamwork and sharing practice amongst *teachers* was also cited as a positive support. These teachers also mentioned that sharing resources could be a helpful strategy.

In keeping with their description of difficulties in teaching problem solving, in Finland, being offered more time was suggested as a potential support. With ample time, sufficient practice and training in problem-solving skills can be developed. Similarly, ensuring that teachers themselves give students sufficient time to work on a task without interruption was deemed especially helpful.

Other ideas which were briefly mentioned were making problems funny, enjoyable, or relatable for students, and in Denmark, teachers mentioned technology as a potential support for effective problem solving.

What role can/does technology play in promoting problem solving in the mathematics classroom?

There were mixed views on the role of technology for problem solving in the mathematics classroom. Northern Irish teachers pointed out that technology can provide enrichment and make it easier to relate problems to real life. Furthermore, some of the Finnish interviewees mentioned the usefulness of technology as a visual tool and a motivator. In Scotland, some interviewees felt that technology can help students to move past their anxiety.

However, in both Denmark and Scotland (while some teachers saw its value) it was pointed out that technology can act as distraction from the mathematics itself, and that teaching how to use technology can take from the learning in a classroom. The importance of the relationship between student and teacher was highlighted by the Scottish cohort in this context.

How could problem posing amongst students be promoted more?

Several difficulties in encouraging problem posing (alongside problem solving) were pointed out by interviewees, particularly amongst the Finnish cohort. It was suggested that motivating students can be problematic, and that they are not inclined to pose problems naturally without a prize to motivate them. Suggestions to overcome this, however, included creating a safe environment in the classroom and relating mathematics to everyday life as much as possible.

Relating mathematics lessons to real life creatively was also suggested by the teachers from Northern Ireland. It was their belief that this would ensure that the students' learning is relevant to their own experience and could increase motivation for students to pose their own problems. (In relation to this, it was pointed out that it is important to plan and structure teaching, and to ensure effectiveness through differentiation and class discussion). This was backed up by the Scottish interviewees, who highlighted the importance of relevant and useful resources to scaffold learning, as well as encouraging peer learning and discussions to provide support.

All of this was backed up by the Danish responses, which focused broadly on the importance of creating a culture of problem solving and of learning related to real life from an early age.

Students' Beliefs

The second aim of the *Needs Analysis* was to investigate students' beliefs about problem solving in mathematics in each of the five partner countries. In order to do this, it was decided upon the use of the Indiana Mathematical Belief (IMB) scales. This is a Likert-type self-report questionnaire developed and validated by Kloosterman and Stage (1992). It investigates five commonly held beliefs towards mathematical problem solving. These include:

1. I can solve time-consuming problems
2. There are word problems that cannot be solved using simple, step-by-step procedures
3. Understanding concepts is important in mathematics
4. Word problems are important in mathematics
5. Effort can increase mathematical ability

The overall instrument is made up of thirty statements to which respondents give their opinion on problem solving using a five point Likert-type scale. Eighteen of the questions are worded in the direction of favourable beliefs, with the remainder worded in the opposite direction. Respondents were asked to indicate their level of agreement or disagreement with each item; 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree. Scoring on negatively worded items was reversed (i.e. 1 = strongly agree, 2 = agree, 3 = undecided, 4 = disagree, 5 = strongly disagree). Each of the five scales (six statements apiece) are scored separately and there is no overall score. Thus, the range of possible scores for each of the IMB scales goes from a minimum of 6 to a maximum of 30 and a high score on each of the scales would indicate more positive beliefs towards mathematics and problem solving. The instrument was distributed via Survey Monkey to a wide range of students across the partner countries in different parts of the education sector.

The analysis of the data focused on identifying differences between year groups across the five beliefs associated with the IMB scales. The statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences). Some demographics along with the mean score for the five scales are presented for each country, followed by a table showing the variance across year groups.

Republic of Ireland (Secondary Education):

In total, 975 completed questionnaires were returned. The respondents' ages ranged from 12 to 19, with the majority (94%) of students being between 13 and 18. There was a wide range of male (48%) and female (52%) respondents across the different year groups (Figure 1).

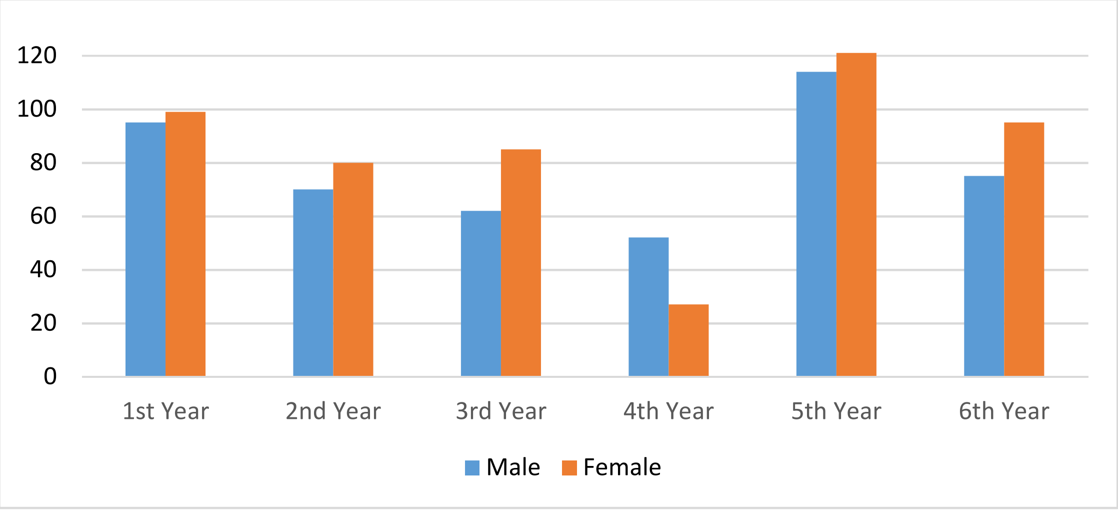


Figure 1. Breakdown of Gender Respondents across the Different Year Groups in RoI

Table 1: Means, standard deviations (n = 975)

Scale	Mean	SD
1. Difficult problems	20.03	4.48
2. Steps	16.30	3.28
3. Understanding	22.71	4.20
4. Word Problems	17.38	3.35
5. Effort	24.04	4.16

Table 2: Mean ratings for the different years, and the ANOVA F and p values

	1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr	6th Yr	F	p-Value
Difficult Problems	21.58	20.66	19.91	19.98	18.86	19.46	9.37	<0.001
Steps	14.77	15.85	16.80	16.44	16.67	17.42	15.3	<0.001
Understanding	23.69	23.93	22.45	21.96	21.98	22.08	7.70	<0.001
Word Problems	17.56	17.25	17.26	17.51	17.35	17.41	0.22	0.96
Effort	24.79	25.35	23.72	23.39	23.29	23.67	6.79	<0.001

Northern Ireland (Secondary Education)

In total, 401 completed questionnaires were returned. The respondents' ages ranged from 11 to 16, with the modal age (23%) being 14 years. There was a wide range of male (49%) and female (521%) respondents across the different year groups (Figure 2).

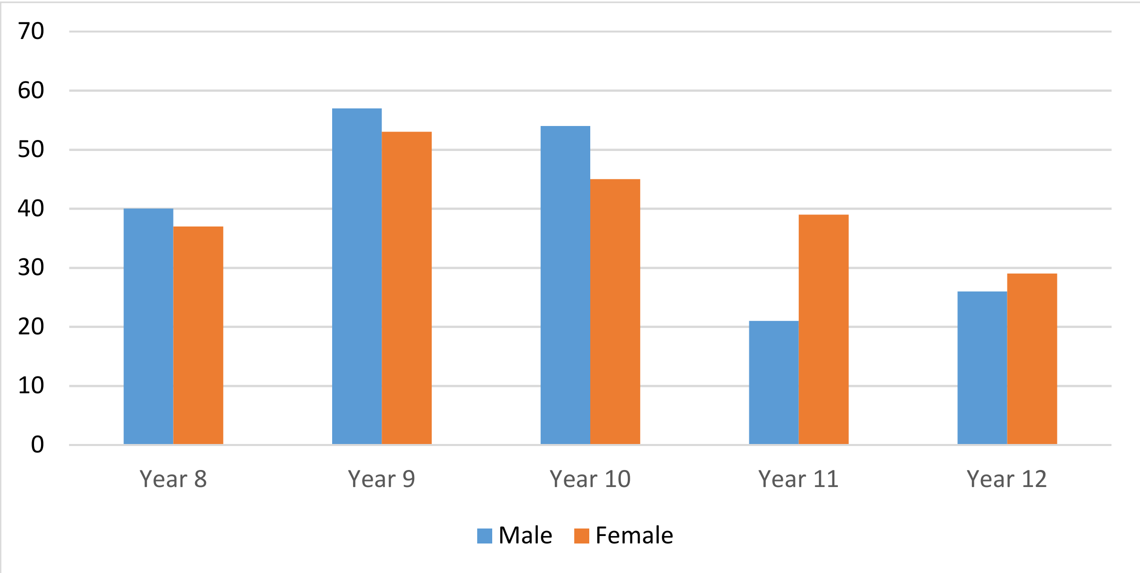


Figure 2. Breakdown of Gender Respondents across the Different Year Groups in NI

Table 3: NI Means, standard deviations (n = 401)

Scale	Mean	SD
1. Difficult problems	19.75	3.74
2. Steps	15.28	2.45
3. Understanding	21.89	3.27
4. Word Problems	16.89	2.4
5. Effort	24.41	3.05

Table 4: Mean ratings for the different years, and the ANOVA F and p values

	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	*F*	*p*-Value
Difficult Problems	19.36	20.28	19.95	19.02	19.64	1.43	0.22
Steps	15.22	15.89	14.97	16.97	15.07	2.50	0.04
Understanding	21.18	21.97	22.12	21.90	22.27	1.25	0.29
Word Problems	17.14	16.74	16.47	17.27	17.15	1.60	0.17
Effort	24.26	24.27	24.53	24.22	24.85	0.49	0.74

Finland (Vocational Education)

In total, 166 completed questionnaires were returned. The respondents' ages ranged from 16 to 47, with the modal age (36%) being 17 years. Once again there was a good spread of gender with 52% of respondents being male and 48% female.

Table 5: Finland Means, standard deviations

Scale	Mean	SD
1. Difficult problems	19.46	4.37
2. Steps	16.16	2.69
3. Understanding	21.37	3.98
4. Word Problems	17.93	2.97
5. Effort	22.31	4.78

Table 6: Mean ratings for the different years, and the ANOVA F and p values

	Yr 1	Yr 2	*F*	*p*-Value
Difficult Problems	18.99	19.96	.84	0.48
Steps	16.37	15.92	2.63	0.05
Understanding	20.93	21.83	.84	0.48
Word Problems	18.07	17.85	.34	0.8
Effort	21.91	22.80	1.03	0.38

Denmark (Secondary Education)

In total, 170 completed questionnaires were returned. The respondents' ages ranged from 12 to 17, with the two modal ages (both 29%) being 13 and 14 years. Once again there was a good spread of gender with 46% of respondents being male and 54% female.

Table 7: Denmark Means, standard deviations (n = 170)

Scale	Mean	SD
1. Difficult problems	21.10	3.73
2. Steps	16.58	2.64
3. Understanding	23.26	3.34
4. Word Problems	17.71	2.16
5. Effort	25.24	3.40

Table 8: Mean ratings for the different years, and the ANOVA F and p values

	Yr 6	**Yr 7**	**Yr8**	**Yr9**	**Yr10**	***F***	***p*-Value**
Difficult Problems	20.89	20.41	21.68	21.24	21.80	.88	0.45
Steps	16.74	15.94	16.72	16.88	19.20	2.20	0.07
Understanding	23.04	23.81	23.22	23.24	19.20	2.32	0.06
Word Problems	17.70	17.26	17.88	18.32	17.40	1.19	0.32
Effort	25.37	25.70	25.27	14.96	20.60	2.72	0.03

Scotland (Adult Education):

In total, 11 completed questionnaires were returned. The respondents' ages ranged from 35 to 75. There were 6 males and 5 females.

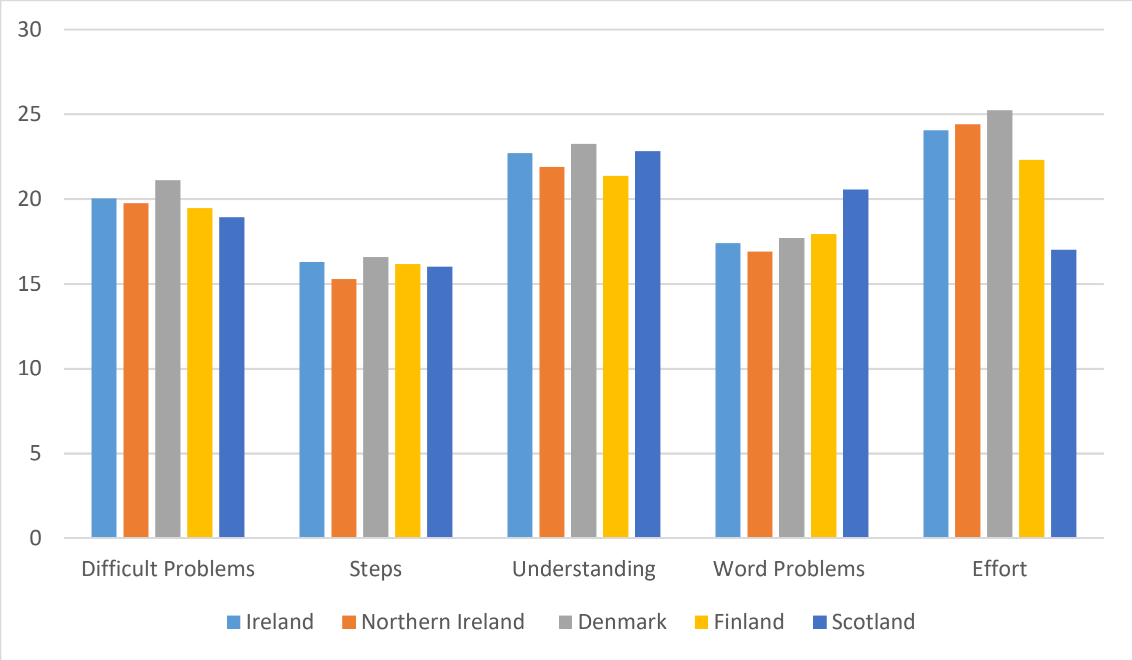
Table 9: Scotland Means, standard deviations (n = 11)

Scale	Mean	SD
1. Difficult problems	18.91	2.95
2. Steps	16.00	3.85
3. Understanding	22.82	3.89
4. Word Problems	20.55	2.97
5. Effort	17.00	7.25

Comparison of beliefs between countries

It is clear from Table 10 that across the five countries the mean ratings for the Steps and Word Problems constructs are low in comparison to the other beliefs, with beliefs relating to the importance of Understanding and Effort ranking highly.

Table 10: Mean scores of each country (n = 1723)



Thus it is be recommended that the Project Team focus on improving students' beliefs for the Steps and Word Problems constructs in the Guidance and Training deliverables.

- In relation to the Steps construct, students frequently believe that there are set rules and procedures to follow in mathematics. However, in order to become successful problem-solvers, they cannot depend solely on their knowledge of routine mathematical procedures. Good problem-solvers have the capacity to solve more complex word problems through the adaptation of these rules and procedures to unfamiliar contexts.
- In relation to the Word Problems construct, there are often misconceptions between genuine word problems and worded descriptions of exercises solved by routine mathematical operations. As practitioners we must exercise caution in distinguishing real problems as opposed to those with words merely wrapped around computational exercises.

For further information
Please contact the coordinating partner info@csscni.org.uk or visit our website https://www.csscni.org.uk/erasmus

Project partners

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