

Qualitative Analysis of Focus groups following a pilot roll-out of NUMBAS with first year UCC  
and CIT students undertaking a Mathematics module.

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This report examines the experiences of students in CIT & UCC using the Numbas tool to complete a series of mathematic exams throughout their first year of college. Three interviews were analysed for this report: One with a group from UCC, one with a group from CIT and a one-to-one interview with a student from CIT who was registered with the disability support services. Questions took the form of a semi-structured interview regarding student's experience of using the Numbas tool.

#### *Approach to the analysis.*

Students were located in UCC and CIT. Given that there were some differences in the delivery of Numbas to students in each institution the data from each group was first analysed separately and then the data was merged to examine patterns both within and across the groups.

#### *Thematic Analysis.*

Thematic analysis (Braun & Clarke, 2006) was used to examine the experience of students using the Numbas tool. Thematic analysis is a qualitative method for the analysis of utterances (speech) or text. It is particularly useful in cases where there are no expectations as to the findings of analysis – allowing the narrative of the interviewees to drive the development of categories and themes based on their own experience. This type of analysis is most effective when the collection of data is consistent. This is achieved by developing a semi-structured interview schedule, which is then used across focus groups and interviews with participants. Questions must be open-ended and unbiased. On examination of the audio files it was determined that this was the case and the data was therefore suitable for thematic analysis.

#### *The Analysis Process.*

The data was subject to thematic analysis. Thematic analysis is a reflexive process. As the researcher works through the data interviews are listened to, read and re-read. Codes are examined and patterns identified.

The interviews were transcribed. Then each interview was subject to open coding. Each phrase being assigned a code that captured the essence of the phrase. For example: “You were kept on your

toes the whole time.” Was coded as “Building knowledge consistently.” Codes were then sorted into categories, similar codes being sorted into the same category. Memos were kept throughout the analysis.

Memos include notes on emphasis (by interviewees), frequency of codes and exceptions. Memos also relate to the categorisation process and ensure that categorisation of codes is optimal. Once the initial open coding is completed categories are then re-examined and, if necessary, resorted for accuracy. Categories are then named. Relationships between categories are then examined. For example ‘Usability’ relates to “making suggestions for improvement” – one being a function of the other. It should be noted that frequency of codes does not necessarily denote importance. One code relating to a participants experience may have greater importance than a code that emerges more frequently. In this case frequency often noted issues that were of concern to the participants and this is reflected in this report. This is particularly evident when categories that emerged for each group are compared. The experience of each group was different, particularly regarding difficulties with using Numbas. Therefore the absence of codes in one group compared to the other represents an absence of experience of that issue. For example the UCC group described finding it difficult to timetable Numbas into their schedules due to other classes, work and commuting commitments. This was not a category that arose for the CIT group, as Numbas was completed during class time.

### *Participants.*

The purpose of the research was to evaluate Numbas as an effective tool for the delivery of online assignments (consisting of a series of exams) for students undertaking a compulsory maths module as part of their first year course. Students undertaking the course came from various disciplines for which a fluency in maths is desired or essential. Courses ranged from the natural sciences such as chemistry, physics and biology to financial management. Focus groups were drawn from this population. Students were invited to participate in the focus groups by email, a small incentive was offered for participation.

*Materials/Instruments.*

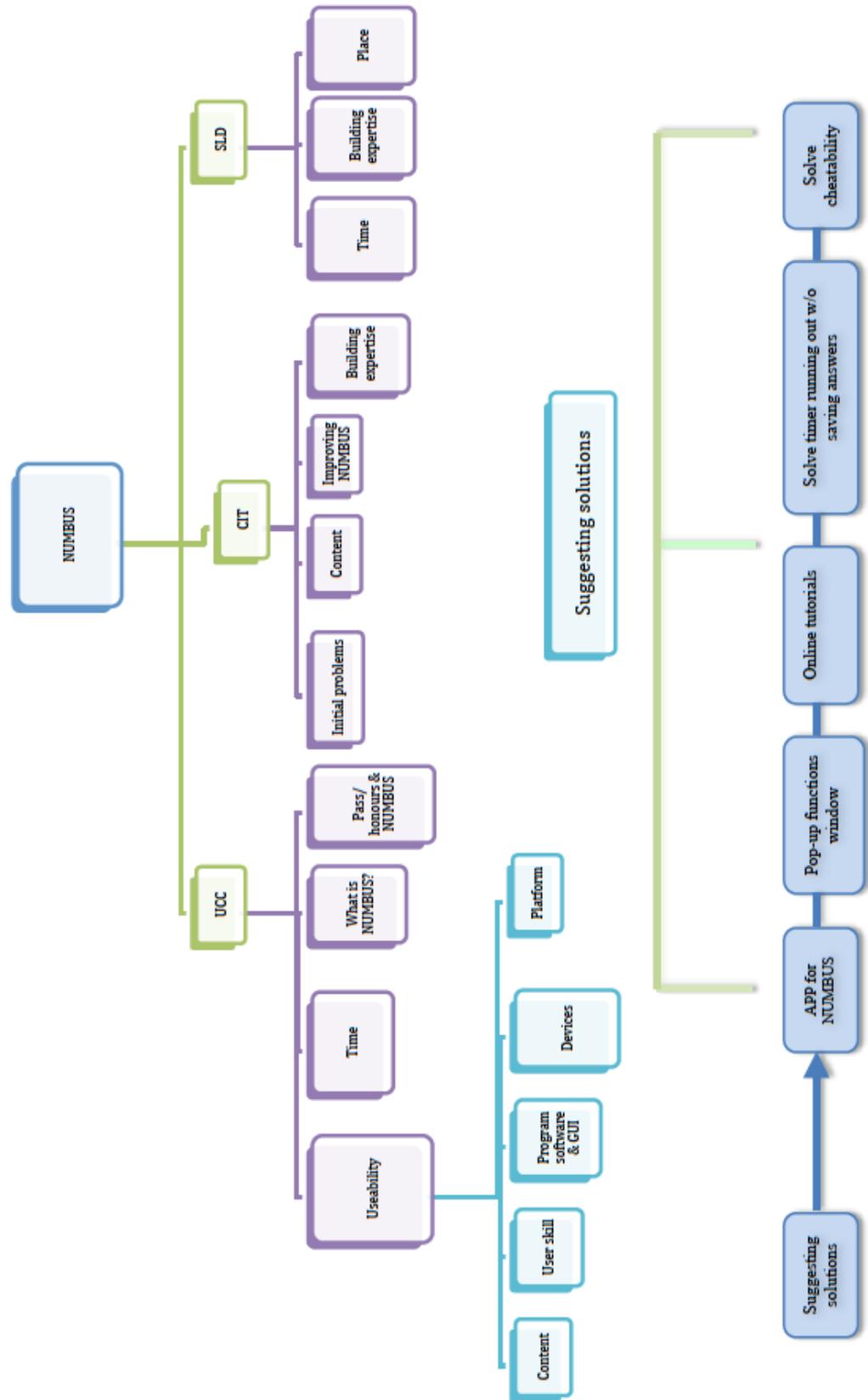
Materials consisted of a semi-structured interview designed to evaluate the user experience of the Numbas tool for use as an online examining tool.

Audio recorders were used to collect data in MP3 and m4a file format.

Interviews lasted an hour and 18 minutes in total: UCC 42.42, CIT 25.32, SID 10.13

Results.

Figure 1 describes the categories that emerged for each group:



Results from each interview are presented below. These results are presented discreetly from each other to give a clear reporting of the experiences of each group. A discussion of the second analysis: similarities and differences in experiences of each group will then follow.

*The Experience of UCC students in using the Numbas tool.*

*Analysis.*

Data for this analysis was sorted twice as there were a number of codes that did not fit into the original first open-coding. It became evident that a number of codes pertaining to usability actually referred to how students circumvented the system – and those students who circumvented, or identified ways of circumventing the system, were more likely to have taken honours maths in secondary school. Conversely students who had taken pass maths tended to engage with the tool, rather than ‘cheat’ the system and had a different experience of using Numbas. Data was therefore re-sorted. For main categories emerged during analysis, these were: usability, time, what is Numbas and Pass/Honours & Numbas.

*Usability.*

The largest category for this group. All students commented on issues of usability. While there was positive feedback, this group focused mainly on their negative experiences of Numbas; however the way in which students phrased criticism of the system was not damning – rather the difficulty experienced was stated and a solution suggested.

“Once you actually got into the system, it worked fine. It was sometimes getting in was the problem.” (M1, UCC).

It was clear that students saw the advantages of using Numbas and saw the focus group as a type of constructive discussion regarding the tool.

There were five levels to the usability category: content, user skill, program software & GUI, devices and platform (Blackboard).

### *Content.*

Students generally had a positive response to design of questions in Numbas. There was positive feedback regarding the intuitive nature of the program and the flexibility afforded when entering answers. The focus group also endorsed the standard of questions; however the complexity of questions was commented on, the nature of the structure of Numbas not allowing of a progression of difficulty within a question (as compared to paper exam questions).

“Yeah, and even a written exam will also include theory on top of that and even the little trick questions.” (M3, UCC).

The most prevalent comment regarding content was the repetitive nature of the tool – being able to rotate through questions allowing a user to figure out how to do a question and then successfully complete a very similar question (only the numbers changing). Students thought feedback on answers was inadequate or difficult to understand.

“Better, better explanations or maybe several explanations, do you know, for answers because some of the explanations were, like, very difficult,”

Students reported that Numbas provided a good basis for study.

“I think it was good. It built up a very good groundwork in Maths. “ (M1,UCC)

### *User skill.*

There was agreement in this group that level of IT skill impacted their experience of using Numbas.

“People like me who struggle with technology, I found it very hard to try and figure out how to put the answer in.” (F1, UCC).

Some interviewees commented that they did not know how to bring up certain functions on Numbas, in particular how to create super-scripts and sub-scripts. Even students who had a fluency in IT conceded that they had difficulties using the tool.

“It looks like Java Script to me and I could be wrong because if it's Java Script then the powers things are a really common problem. If it's not, then it could just be bad luck.” (M1, UCC).

Students compared their experiences with Moodle – which they reported as more user-friendly in

this regard. Usability was dependent on the users fluency in using shortcut keys for scripts and certain mathematical functions. Lack of fluency with these shortcuts impacted ease of use.

“As far as the concept, as a concept and as an idea goes, it's pretty well done. The technical issues though stopped it from being anything really kind of different.” (M1, UCC).

There was a high frequency of comments regarding difficulty in submitting answers on Numbas. Many students reported having issues submitting completed answers successfully. Students seemed unclear regarding the procedure for successful submission – weather they had to click ‘submit’ once or twice. They also reported running out of time and being unable to submit their work when the timer had lapsed.

“I think, our eighth exam, we stopped using it because, like, say, the vast majority of the course which is a very large amount of us, so it was probably 200 plus of us were finding it too difficult to submit.” (F2, UCC).

Students also commented that Numbas did not accept correct answers on occasion, a comment that is echoed in the CIT data.

One of the factors regarding accessing Numbas on campus for UCC users was the availability of multiple computers, as some students worked in groups to complete the assignments.

#### *Program software and GUI*

Many of the IT issues experienced by the students were attributed to either the software programming or the user interface. Students suggested fixes such as a pop-up window for calculations and switching to super and sub-scripts. The size of the window for Numbas, as it appeared on Blackboard was reported a sub-optimal, with sometimes poor resolution.

#### *Devices*

There was a high frequency of codes regarding the type of device upon which users accessed Numbas. Usability depended on device used – PCs in the university being most useable, while phones and tablets less so.

“... I have a computer at home. I don't want to really use it either on a computer myself but I

know that a lot of people have tried to do them on their tablets and struggled with it.” (M2, UCC).

Some students reported not knowing they could access Numbas on their phone, while one participant reported being unable to access Numbas on their phone.

“and he doesn't have access at all in his phone to it. It kind of just won't come up at all. It would be like, the website was blocked or something like that and they just didn't work for him, so he had to go and find a computer or something, like. So it kind of needs to be sorted as well. If it was easy to use on phones, then we would be able to use it on every type of phone.” (F2, UCC)

Campus Wi-Fi was reported as being an issue when trying to access Numbas on a personal device in college.

#### *Platform*

UCC users accessed Numbas through Blackboard, the university's learning interface.

“I think the biggest flaw was that it was, you accessed it through Blackboard.” (M1, UCC).

Students reported a number of difficulties with Blackboard including downtimes during the assignment time-window, blocked pop-up windows for Numbas, speed, visibility of the Numbas tool and quality of resolution of the Numbas window.

“The second time we used the Numbas system, there was a server maintenance kind of like from 5 until 7 that day.” (M3, UCC).

#### *Time.*

Time was a large category for UCC students. In particular students reported not being able to attend initial tutorials on Numbas due to other course commitments (other tutorials and labs). This may be a factor regarding IT difficulties experienced for this group, as an initial introduction to the tool would have addressed some of the issues they grappled with.

“Interviewer: Was the one tutorial not sufficient, do ye think?”

Participants: No.

Not everyone can get to tutorials with college.

Not unless we have online tutorials, we can't.

Yeah, and when you first set up your account with the Numbas, like, tutorials teaching you how to do all these things like the powers and all that, you know, for..."

There were two main sub-categories to the time category for UCC students – the window of time available to complete the exams (Wednesdays from 4pm-9pm) and the time within which the exam had to be completed.

*Timeframe.*

Students reported difficulty time-tabling Numbas into their schedule within the timeframe available. The timeframe available posed problems in terms of other commitments – in particular other classes, commuting and accessing devices on which to complete the exam. The time window available clashed with other tutorials and labs for some students.

“That wouldn't be as big a problem (finding a device upon which to complete exam) if we didn't have the five-hour time limit because if you constrain people with that five hours, people working, have lab, etcetera.” (M1, UCC).

Students questioned the workability of a timeframe, rather than a scheduled time to complete the test. This discussion is teased out in the focus group. Students finally suggesting that the timeframe be widened too accommodate other commitments students may have.

“All that, all those kind of submission problems could probably be helped in a great way by extending the timeframe from five hours to 20 or at least 12, probably 24 hours.” (M3, UCC)

In terms of the window of time designated to complete the test students particularly struggled with the timer running out and therefore being unable to submit. Some students stated that the time allotted was restrictive; on the whole students felt that the time allotted to complete questions on Numbas was good.

### *Pass/Honours and Numbas.*

One of the interesting things to develop from analysis was the difference in experiences of students in interacting with the Numbas tool depending on the level of maths they had studied in secondary school. Students who had taken pass maths generally reported finding Numbas useful in improving their understanding and expertise in maths – allowing them to engage more effectively with their courses at third level:

“I feel like the fact that the NUMBAS system is a little more advanced than what I do remember of the Leaving Cert calculus but not quite as dense as university level. It's a nice ... Like, if you were struggling.” (M3, UCC)

“It is a good tool for First Years to use to build up their levels of Maths, like. I did Ordinary Level Maths too, and it was just easier for me to build up to the college level Maths.” (F2, UCC).

Students who had taken honours maths generally discussed the repetitive nature of the questions – the ability to chose another iteration of a question, and hence how to manipulate Numbas:

“It was very easy to manipulate it in such a way as to basically make it useless because basically the feature of being able to create a new answer, that was very easily manipulatable...it was very easy for most of the questions we had to just get it to show you the answer, read a whole new question and get the exact same question and just put in the answer.” (M2, UCC)

Pass students also emphasised the importance of finding computers together on campus, so that they could work on Numbas as a group. Therefore some students found ways around the tool, while others consulted with each other to complete the assignment. Students recognised that this poses problems if using Numbas for evaluation of students work in a more comprehensive way.

### *What is Numbas?*

A number of codes related to the purpose of Numbas. Students either endorsing or questioning its function. There were a number of codes relating to the future uses and functions of Numbas.

“Once you're in Second Year, you already have the First Year Maths behind you. You know what you're doing, like, so it is easier just for First Years.” (F2, UCC).

Students endorsed Numbas as a homework and revision tool and for a small proportion of their marks for the module overall but there was resistance to conceiving of Numbas as an exam:

“...if it were to be implemented in such a way that it was focused less on being a substitute for exams and more of being a homework system, then I think it would be fantastic.”

Students were aware that Numbas was an exam of sorts and struggled with the concept of completing it in a flexible timeframe. They challenged the idea of using Numbas in a more widespread manner and were dubious regarding its use in years where grades would go to final degree marks.

“I think it would be very wrong to have it applied to Second Years or Third Years and most importantly, like, Fourth Years or final years because that's their degree. Like, if there's any chance of losing even five, ten marks because of this system, that can be the difference between an Honours degree and, like, an Ordinary Level degree for people.” (M1, UCC).

### *The Experience of CIT students using the NUMBAS tool*

#### *Analysis.*

Analysis of CIT data resulted in four categories: Initial problems, content, devices and building expertise. Data was coded and categorised. Initial open coding resulted in a clear structure for the data. It should be noted that while some of the categories identified are similar to that of the previous analysis the experience of the students differed.

#### *Initial problems.*

Overall students had a positive experience with using the Numbas tool. Students reported having initial problems with using the Numbas tool such as accessing the tool off-campus and submitting work. These problems were quickly resolved however and the experience of students thereafter was that, on the whole, Numbas worked well.

“After that problems didn’t really arise.” (M1, CIT)

Some issues persisted. Students commented on the issue of time lapsing prior to submitting work:

“One thing I found annoying was the timing that automatically wipes and it doesn’t submit.

So it’s just wiped the answer. There was nothing I could do, I couldn’t submit.”

“I think that’s the one thing we should be warned about.” (M2, CIT)

Students reported that tutorials attended contributed to their understanding of how to use Numbas, some stating that this was an essential element of ease of use when using the tool.

“There was good attendance at tutorials because of Numbas...It has to be properly explained.” (M1, CIT)

#### *Content.*

Students gave positive feedback regarding the content of Numbas.

“Yeah. I thought NUMBAS was really good because it was a way of being tested a little bit every few weeks so that we then, when you went to a big exam, you kind of knew what you had but also during the year, it kind of kept it fresh in your mind, like, the topics you were doing, like, in class and in the labs and I thought it was good that way.” (M1, CIT)

Participants felt feedback (explanations of the answers) was poor however, explanations being complicated or inadequate at times. Students also stated that, on occasion, Numbas would not accept the correct answer to a question. Instant feedback from lecturers, confirming that this was probably an error, assuaged stress for this group.

“problems didn’t really arise but when they did, like, if you were doing a question over and over again and you kept getting it wrong and you couldn’t see, you would have your lecturer then saying, “Oh, you’re just going wrong there,” so then you knew it then for certain, like, rather than trying to guess it yourself.” (M1, CIT)

Students felt the instant feedback regarding accuracy of answers on Numbas was a useful feature.

They expressed feeling ‘instant satisfaction’ when seeing a series of ‘green ticks’ as they completed the exam. Students also felt this motivated them. As students completed the exam in-class other

students could observe their progress in terms of green ticks and so students wanted to do well.

Students interacted with the tool in a positive way some saying it ‘was like a game.’

Students felt however that the absolute nature of the marking scheme was harsh, commenting that no marks were awarded for attempts that fell short of the correct answer.

“I thought it was nice to be able to get immediate results but I disliked the fact that you couldn’t explain your answer and you could only give a answer, and there was no marks for attempts.” (M2, CIT)

Students criticised the perceived lack of clarity regarding entering answers to one decimal place, even though this is stated in the tool, they felt it was not clear enough given that they were not used to this approach.

Some students reported having difficulty with specific areas, such a binomial distribution and probability.

#### *Devices.*

There were several codes for the student’s experience of using Numbas on various devices.

Students commented that being able to use Numbas on their mobile phone was useful. While some students didn’t realise it was possible to access Numbas on their phone, others said the tool did not work on their phone. Students completed their tests in-class, which positively impacted their perception of using the tool. Asked what would they think of the process if they had completed the tests in their own time students commented that Numbas would appear like homework, there would be less importance placed on completion, implying that they would be less conscientious in completing the exams.

“Yeah, where you could be just on Facebook or whatnot or ...

Yeah.

Also if it was allocated from home, maybe people might feel that Numbas is more just like homework ...

Homework, yeah.

They'd be doing it last minute and they wouldn't remember it"

*Building expertise.*

CIT students endorsed Numbas as a learning tool and one that directly related to the content of their course, identifying weak areas and encouraging targeted study of those areas:

Students often used Numbas as a revision tool.

"I think Numbas is the best indication of how you're doing throughout the year." (M3, CIT)

Working with NUMBAS motivated students to work consistently:

"You're doing more study, probably more than you've ever done." (M1, CIT)

*Experience of a student (CIT) with a specific learning difficulty and NUMBAS.*

*Analysis.*

This was a short interview, with fewer data-rich phrases than the focus groups. It should also be noted that the interview was less robust than the other two. Nonetheless some pertinent data emerged and while it is limited, the analysis is nonetheless useful. The participant did not report many issues with usability:

"I kind of, I practiced it mostly in college on the desktops and it was, it always worked fine there. I thought it was very easy to operate. There was nothing overly tricky about it. It definitely improved my Maths during the year." (M1, SLD)

Many of the codes confirmed experiences of students in the other interviews including finding tutorials useful or essential and encountering errors in the system.

"...and there was a couple of them where the answers, they weren't right, well, our lecturer reckoned they weren't right, so I remember one day in particular, it was, like, there was only one answer to this particular question and normally there's three or four. But I think it was

in Financial Maths, and I was working on it for a good while trying to figure out how they got it, but it was actually a mistake in the system, so ...” (M1, SLD)

Like the CIT focus group, the interviewee commented on the usefulness of tutorials in terms of usability of Numbas.

“You wouldn’t know, you wouldn’t be able to do the Numbas really. Well, it would be a lot harder if you didn’t go to them, was what seemed to be what people were saying because I went to, I went to nearly all of them, I think. “ (M1, SLD)

The relevance of the material covered was also an issue:

“...so I didn’t mind it, but I know the overall vibe in my class was that they didn’t really see the point of it. Like, it’s a level seven Business Studies course and we were learning about probability of different things.” (M1, SLD)

#### *Time.*

The participant commented on the fixed time required for completing the exam – while the student had an overall very positive experience using the tool there were no allowances made for their specific learning difficulty (SLD).

“The timing. I didn’t ... Like, I have dyspraxia so I didn’t always get it finished on time or if I did, it was a rush.” (M1, SLD)

#### *Building expertise.*

Building expertise was the largest category for this participant, the student strongly endorsed Numbas as a tool for gaining fluency in maths:

“Because it was a great foundation to have going into the last few weeks of college because we had been studying it consistently throughout the year and that was, that was a great help.” (M1, SLD)

While other students commented on the lack of complexity of questions the student reported liking the format and the ongoing learning that Numbas involved was useful.

“Maths wouldn’t have taken up all of my study either but when I studied, I used Numbas.” (M1, SLD)

*Suggesting Solutions – a common theme.*

Throughout all three datasets students recommended solutions to the issues they had had with Numbas. As stated earlier while there were a number of issues with the system, students remained positive regarding their experience of the tool.

For example students recognised that the tool could be manipulated and recommended a fix.

“...introduce a limiting factor that would kind of make that hack, I guess, or that way of getting around it, it would make that null and void. Also it would, you could, basically you could spend one of those guesses to having show you the answer.”

Likewise the designing of an app for devices was suggested.

Regarding the time window for UCC students, students recommended widening the time window to 24 hours or having supervised sessions (although they equally commented that this may defeat the purpose of the online element of the course). While the SLD student recommended providing a wider timeframe for completions for students with SLDs:

“...maybe if there was an allowance for extra time because I have dyspraxia, like, and if I was doing a written exam, I’d have 10 minutes for every hour. “

Compulsory tutorials and more comprehensive online help (in the form of tutorials) were recommended by UCC students.

“When you first set up your account with the Numbas, like, tutorials teaching you how to do all these things like the powers and all that, you know.” (G2, UCC)

An on-screen calculator, or pop-GUI for super-scripts, sub-scripts and other notation.

“...so some kind of feature that allows you to easily change it to superscript and back again without having to, you know, use shift plus or shift minus.” (M1, UCC)

Some students who commented that they worked in groups did not see collaboration as an issue:

“(the person working with me)...would have a similar type of question as well, you know, a similar enough question, with numbers, you know. I thought it was kind of helpful in some way because we were working in pairs, you know, so if one person didn’t get it, the other person might have it and then we could just help each other.” (F2, UCC)

While others did:

“ it defeats the point of it being an exam because, you know, we can just communicate with one another. So it would have to be supervised. “ (M1, UCC).

Students reported that the tool would need to be cheat-proof if it were to worth more than 20% of their grade and had doubts regarding using it for years other than first year.

Regarding issues such as time lapsing prior to submission clearer warnings might be given, this also applied to how many decimal places were required.

*Discussion – similarities and differences.*

Finally the data was merged and re-examined. Some interesting contrasts of experience were apparent.

*Usability.*

The frequency of codes for this category was much higher for UCC students and CIT students had a much higher rate of codes endorsing the usability of Numbas. In fact the experience of CIT students was largely positive. Usability of Numbas was impacted primarily by having a working knowledge of the tool, its functions and possible pitfalls when submitting work. CIT students received a higher level of support due to a higher attendance at initial tutorials and the supervision of the exams themselves. This resulted in the category ‘initial problems’ emerging for the CIT group in the initial coding, indicating that issues with the system were resolved at an early stage rather than ongoing. UCC students struggled with usability due to their lack of fluency with the tool and due to their relatively low attendance at tutorials; this was due to timetabling and commuting issues, there was also a lower attendance rate for leaving cert honours students because they didn’t feel they needed to attend. UCC students also struggled with accessing the tool through Blackboard, generating

symbols, the size of the tool window and resolution of the interface.

Therefore UCC students had a very different experience of usability than CIT students.

Interestingly UCC students still endorsed Numbas and gave positive feedback regarding their use of the tool once teething issues and other barriers to usability were factored-out.

Usability on tablets and phones and accessing Wi-Fi was also a bigger issue for UCC students as CIT students all completed exams in-class.

#### *Time.*

The largest contrast was the experience of time for each group. Both groups commented on the timeframe for completing the exam but negative feedback was minor in this regard across all three groups – although the comments regarding extra time allowed for SLD students is worth noting.

UCC students had a high frequency of codes relating to the five-hour window for undertaking the exam and attending tutorials.

#### *Place.*

Where students completed the exams using the Numbas tool impacted their experience of the tool in very different ways. CIT students described feeling motivated to succeed due to the supervised nature of the completion of the exams. That other students could see at a glance how they were doing also impacted performance. It should be noted that this study represents a very small sample of students from the groups – other students may find the public nature of their success or failure prohibitive. UCC students struggled to find computers upon which to complete the assignment on-campus. The flexible and unsupervised nature of place resulted in students completing the exam in groups. CIT students tended to separate the practice of Numbas from their exam sessions – and while both groups endorsed Numbas as an effective learning and revision tool, the frequency of codes for building expertise was higher in the CIT and SLD interviews. Frequency of codes relating to how to manipulate the system was also higher in the UCC group. As a result of the flexible time-frame and place available to UCC students how they saw Numbas differed from CIT students – with a higher frequency of codes in the UCC group relating to resistance to using Numbas as an

exam tool. UCC students instead endorsed Numbas as a homework and learning tool – a compliment to exams rather than a potential substitute.

“ ...with the Numbas system because it's defined as an exam, whereas I feel like it shouldn't be thought of as an exam, but more like homework or it's all assessment. “ (M2, UCC)

#### *Suggesting solutions.*

It should be noted that some students may have suggested solutions to issues they perceived as problematic due to their lack of fluency in using the tool and that this analysis reflects their experience rather than a comprehensive view of the functions and objective usability of the tool. That this may be the case is reflected in the inconsistency of user experience both within and across groups. Overall the nature of suggestions for solutions was orientated around the previous three categories. Both groups suggested solutions to issues of submission of answers in the tool itself and producing super-scripts and sub-scripts without using keyboard shortcuts. UCC students suggested solutions to usability across devices and online solutions to issues that arose for them – such as usability of the tool through Blackboard and on certain devices (developing a universal Numbas application to circumvent these problems) and the development of a more comprehensive in-tool tutorial for Numbas.

#### *Conclusion.*

Overall students described enjoying using the tool and the usefulness of Numbas in improving maths skill to a level required for third-level study was endorsed. The difficulties in rolling out an online, unsupervised exam are evident given the feedback from UCC students. However it should be noted that there was high endorsement of the tool across groups, the consensus being that Numbas has the potential to be an effective learning tool once initial bugs are resolved.

