

Motivating Factors and Barriers for Sustained Use of Audience Response Systems - “I would love to, but I don’t have time :(”

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Abstract—Audience Response System (ARS) usage in lectures has grown in the higher education sector over the past decade with the evolution from hardware “clickers” to web and mobile-based systems due to the ubiquity of mobile internet and mobile computing devices. Benefits of ARSs for instructors include the capability to receive real-time feedback on student understanding, breaking up lecture time, increased student engagement and improved learning outcomes. The interest in, and understanding of, the perceived benefits of ARSs are often sufficient motivators for instructors to trial this technology. However, the sustained use of this technology presents a hurdle for some instructors, beyond the difficulties in initial uptake. This paper investigates the motivating factors and barriers for sustained use of Audience Response Systems.

Engineering instructors were interviewed in addition to a university-wide survey using an instructor technology adoption framework. This framework was used to study participants’ “pedagogical beliefs”, “knowledge”, “self-efficacy”, and the institutional “culture” with respect to ARSs. The findings suggest that culture and pedagogical beliefs were the primary themes with respect to enabling sustained use, while knowledge and self-efficacy were secondary enablers. The major barrier for sustained use was “time”, which was an aspect that appeared in multiple themes. This identification and understanding of the motivating factors and barriers for sustained use for ARSs has helped advance the design and development of departmental support and a bespoke ARS software tool.

Keywords—audience response systems, educational technology, active learning, higher education.

I. INTRODUCTION

In light of ever-growing class sizes in engineering courses, the ability to scale student-instructor interactions and to maintain positive student engagement is a pertinent pedagogical aspect that requires great attention. Fortunately, increasing class sizes have occurred in tandem with two significant technological trends, namely, the ubiquitous availability of wireless internet access and the saturation of the smartphone market.

According to [1], smartphone adoption among Australians aged 18-24 (the primary demographic of undergraduate students in Australia) reached 95% in 2017 - up from 94% in 2016. This is indeed part of a global trend [2] and as such, a myriad of smartphone-based solutions have been generated to resolve the challenges that result

from increasing class sizes. Among these technologies, ARSs have been shown to be an effective way to address these challenges [3].

Research investigating the impact and effectiveness of ARSs on student learning and engagement is extensive [4]. ARSs provide students with the opportunity to respond to “polls” posed by the instructor pseudo-anonymously (students are anonymous to each other, but not to instructors) and in real-time. The polls can be designed to address common student misconceptions and have been found to be an effective instructional tool as instructors are able to adjust their teaching depending on the real-time feedback they receive [5]. The first ARS was implemented at Stanford University in 1966 [6], though at the time, the technology was far more complicated and too expensive for widespread acceptance. Today, technological advancement, ARS evolution and the realization of its benefits have resulted in these systems becoming increasingly popular in higher education [7].

The two primary advantages of using ARS from a student perspective are that (i) participation remains anonymous to a degree and (ii) students have the opportunity to test their understanding or receive immediate feedback if they have misconceptions in class. This engages reluctant participants and has been shown to provide a more effective learning environment, which results in improved learning outcomes [8]. Additionally, it has been shown that a student’s academic performance positively correlates to the amount of participation put forth by the student [9]. Many of the studies conclude with students feeling satisfied with the system [10].

From an instructor perspective, ARSs can serve to record class attendance, motivate participation, maintain student engagement throughout a lecture, and gather real-time information on students’ comprehension of concepts. Thus, instructors may adjust the pace of their lecture, provide clarifications on misconceptions and facilitate “peer instruction” (a form of peer-assisted learning) if desired [11].

A growing body of research has developed around the adoption of ARSs in teaching contexts. A number of barriers to initial adoption have been identified in these studies. Firstly, instructors may lack knowledge in the field of

innovative technologies for teaching and therefore be unaware that ARSs exist. Secondly, inadequate technological resources (e.g. facilities and technical support) and unstable infrastructure can pose serious setbacks to technology uptake [12].

At a higher level, instructor technology adoption in general has been widely studied by researchers such as those in [13] who propose four key variables for successful technology adoption, these being: “culture”, “pedagogical beliefs”, “knowledge” and “self-efficacy”. However, despite many institutions attempting to address these barriers to adoption and despite the proven effectiveness of ARSs, significant barriers for the *sustained* use of ARSs by instructors still exist; few studies in the literature are devoted to understanding why this is the case.

In this paper, we propose that the four key variables for successful technology adoption outlined by [13] can be extended and used as a framework under which the barriers and enablers to *sustained* use of ARSs can be analyzed. In this research, we do so within the context of the Engineering Faculty at [University Name Removed for Blind Review] through semi-structured interviews and a university-wide survey.

II. METHODS

A. Framework

The framework used in this research is an extension of the work by [13] in which we use the four key variables for successful technology adoption - “self-efficacy”, “pedagogical beliefs”, “culture” and “knowledge” - to analyze *sustained* use of ARSs. A detailed description of each of these key variables follows.

Culture	Support from organization.
	Support from and actions of peers.
	Perceived values and beliefs of peers.
	Discussions with peers.
Pedagogical beliefs	Rules of thumb, generalizations, opinions, values, and expectations regarding the use of the technology in the classroom.
Knowledge	Awareness of the tool.
	Knowledge of how to use the tool.
	Knowledge of the content they are required to teach.
	Knowledge of the pedagogical methods that facilitate student learning.
Self-efficacy	Knowledge of the specific ways in which technology can support those methods.
	Instructor's level of confidence in using the technology to achieve learning outcomes.

These variables served as a lens through which the interview and survey data were analyzed, to identify the important themes with respect to enabling the sustained use of ARSs.

B. Interviews

A total of 10 instructors from the Faculty of Engineering were selected to participate in semi-structured interviews ranging between 30 to 60 minutes in length, to share insights on their pedagogical beliefs and experience using an ARS in their instructional practice. Participants were selected based on their usage of an Audience Response System (according to system logs) ranging from avid users to those who tried but ultimately discontinued their use. The instructors were invited to the study via email and 8 agreed to participate in the study. The participants included three senior lecturers, a lecturer, an associate professor, a professor, a visiting professor and an Associate Dean (Research). The affiliations include Departments of Chemical, Civil, Materials Science, and Mechanical and Aerospace Engineering. All participants taught undergraduate units - their teaching experience at the higher-education level varied from 2 to 32 years, and the number of students taught per unit offering ranged from 50 to 600 students.

The questions were designed to invoke responses relating to the interviewee's culture, pedagogical beliefs, knowledge and self-efficacy regarding their use of ARSs. Background questions addressed the interviewee's priorities for professional development, reflective teaching practices and their readiness to explore and experiment with new technology. ARS-specific questions considered the interviewee's experiences with ARSs, their importance for teaching, and their impact on student learning experiences and learning outcomes. These interviews serve as the qualitative basis for this research.

C. Surveys

In addition to the interviews, a survey instrument was constructed from 96 questions pertaining to a number of facets relating to the adoption and sustained use of ARS technology. Emails were sent to 2226 instructors across the university with a prize draw of \$200 gift cards which were randomly gifted to ten participants. The survey was designed to take approximately thirty minutes to complete and of the 2226 instructors emailed, 376 completed the survey - a response rate of 16.9%.

The emergent themes identified from the interviews were then compared with the survey data to establish where the general consensus across the university supported or refuted the interview data.

III. RESULTS AND DISCUSSION

The results of this study are separated into six sections: one addressing the motivators and barriers for *initial* adoption followed by four sections focusing on the motivators and barriers for *sustained* use (one for each of the framework's four key variables) and, finally, a discussion of areas for future work.

A. Initial ARS adoption

Data from the survey showed that when instructors were asked “What is the most important factor that would influence you to use an Audience Response System in your future lectures?”, “students” were the primary focus of respondents’ open text answers. In fact, the word “students” was found to be the most frequently mentioned word with 66 mentions (compared to 27 mentions of the word “lecture” - the next most frequently used word in responses to this question). This suggests that pedagogical beliefs relating to student learning were seen, by instructors, to be their primary motivator. However, the interviews and other survey results revealed that, in fact, *cultural* factors appeared to play the largest role in influencing initial adoption of ARSs. More specifically, support from, actions of, perceived values of, and discussions with colleagues were the more common themes that influenced instructors’ usage of an ARSs. This dichotomy is perhaps best reflected by the following quote:

“Yes, it was the influence from <student evaluations of teaching> and the fact that <name of co-lecturer> was doing it. And I guess the thought that ... maybe ... it's going to help them learn a little bit more. So yes, I mean I didn't feel pushed into it, but neither did I completely voluntarily say yes, this is what I'm going to do. So, it's some sort in the middle ground there.”

The majority of interviewees were first introduced to ARSs either through taking over an existing unit, co-teaching with others who are advocates of the tool, or an onboarding process at another institution. One instructor took over coordination of a unit that had a clicker system and quizzes in place. An interest in increasing student engagement coupled with an existing question bank meant that it was an easy decision for the instructor to adopt an ARS. It was simply a modernization of an existing system. Another instructor had started using ARS because it was the strategy that was set by the unit coordinator and use of the ARS was simply prescribed. After some time, they found the tool to be useful and therefore decided to implement it in another unit that they were coordinating. There was also a case where a visiting academic was introduced to a suite of educational technologies by education-focused staff upon their arrival. In addition to having positive experiences with ARSs at their previous institution, they expressed increased readiness to implement the ARS knowing that it was supported by their new department. Moreover, the departmental support set an impression of how instructors teach at that institution.

In contrast to these institutional and departmental support factors, instructors did not cite top-down institutional pressure as a factor for adopting ARS. One instructor mentioned encouragement from a senior staff member *“our head of department... is very keen on Audience Response Systems being integrated into all of the units to make it a bit more, I guess, mainstream for the students.”* However, in the institution-wide survey, instructors neither agreed nor disagreed with the statement “My direct line manager thinks that I should use an Audience Response System in my lectures” (Fig. 1).

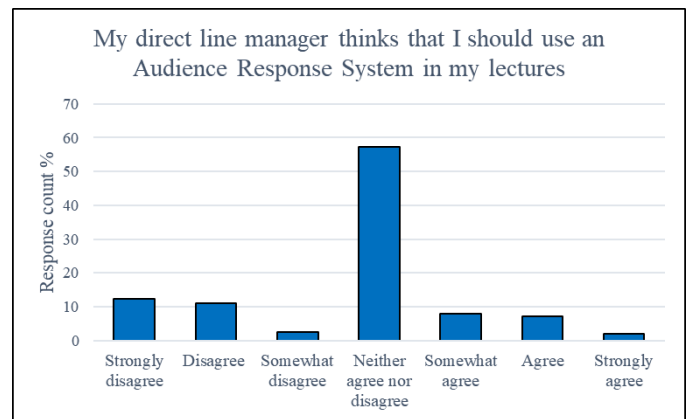


Fig. 1. 7-point Likert scale responses to the question “My direct line manager thinks that I should use an Audience Response System in my lectures.”

It is also interesting to note that ARS-related questions or issues were specifically linked to distinct individuals within the institution. These individuals acted as beacons. *“Everyone pointed me to <education focused colleague>, and that’s where I went for anything I needed”.*

Importantly, the interview participants were not the first to trial ARS in their units and each had a point of reference for support. Hence, these cultural factors facilitated instructors to overcome several knowledge-based barriers for adoption. Furthermore, having direct communication with someone who had experience with the ARS dramatically increased confidence and self-efficacy as they felt readily able to quickly resolve any problems that may have been encountered. Although training documents and user guides were available for the ARSs, many participants found informal one-to-one conversations to be more valuable. The following quote greatly reflects this:

“Certainly, being friends with <avid ARS user> made it easy, because if I had any problems, I'd just ask him. So that made a big difference. I must admit if it was just an email going around from the teaching and learning people saying ‘look, this is a resource you can use’, ... I probably wouldn't have bothered”.

This sentiment was echoed in another instructor’s advice:

“.. it has to have more acceptability or uptake by other academics. It’s powerful - I can easily tell you based on my personal experience. ... [However,] until people are exposed to these new technologies, people won’t buy [into] it.”

These findings illustrate the importance of cultural aspects, particularly those regarding colleagues, on the initial adoption of ARS technology.

While culture was found to be an enabler for ARS adoption, some of those disseminating information regarding the availability and efficacy of these tools were unsure of its impact on their colleagues. An interviewee expressed:

"I've told the other people in my department at departmental meetings it's easy to use, it's really useful. I don't know if others are using it, I'm not sure how widely used it is."

Closing this feedback loop could lead to greater adoption and encourage the aforementioned 'beacons' to continue promoting effective educational technologies.

Indeed, cultural factors aside, it must also be recognized that there were exceptions to this trend of grass-roots-style introductions to ARSs by colleagues. One instructor's use of ARS was spurred as a result of their active attempt to address engagement issues in their class. They described their difficulties in being able to deeply engage with students and to gauge their understanding whilst teaching in a language (English) that was foreign to Spanish students. To quote:

"I had very little way to know. I had no feedback. I had zero feedback. I was teaching a class of 120 students, 130 students that year. I had never taught a class that large before. I am looking at a sea of students, not recognizing one, not getting eye contact with many. So I had no idea, what are they getting, what are they not getting?"

This prompted the academic to seek help from a colleague within the Education Faculty who suggested using an ARS. The effects of the ARS were immediate - the feedback provided an indication of student understanding and provided the instructor with a greater sense of self-efficacy.

There were also some smaller concerns around technology - particularly with respect to smartphone and internet access. One instructor commented:

"Well I think what you would have to do is make sure that every student had access to a decent smartphone, or some device that would allow them to do that... That's another thing, you don't want to be asking questions and then all the students are angry because they can't connect to, you know, eduroam or the free Wi-Fi's not working or some poor kid's in a black spot in the lecture theatre."

While these concerns are important to consider, this sentiment was only expressed by two of the instructors and did not appear to be as much of a consideration in comparison to the other factors. It should also be noted that while, in our context, this infrastructure-based hurdle was not a large issue, but this may not be the case in all institutions.

B. Sustained Use and Culture

Given how prominent cultural factors were in the initial uptake of ARSs, it may not be surprising that they were also found to be a significant theme for sustained use. A number of instructors who discontinued their usage of ARSs mentioned that peer pressure would likely convince them to use it again. One instructor commented:

"If everyone was using it and I'm the one who is kind of struggling adjusting to it, I probably would have forced

myself to use it more often. If everyone was using it. But I didn't really meet people who were using it. So I didn't have that feeling of reinforcement."

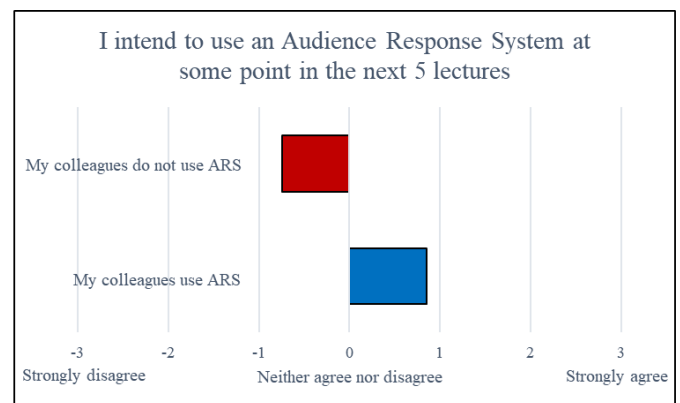


Fig. 2. Averaged responses to the 7-point Likert scale question "I intend to use an Audience Response System at some point in my next 5 lectures" categorized into colleagues who use ARS and colleagues who do not.

This view was supported by the survey data (Fig. 2) in which instructors who stated that their colleagues were using ARSs were more likely to agree with the statement: "I intend to use an Audience Response System at some point in my next 5 lectures" (t-value = -5.86, $p < 0.0001$).

Another cultural barrier was faced by an instructor who was co-teaching a unit. The unit coordinator commented

"So the challenge was not me using it, it was actually to get my co-lecturer to buy into the idea. He said that it was very difficult. My guess is he did not even try. Because he said it was difficult ... I was not approached so in the end he dropped it"

This is a particularly difficult problem for instructors who desire to provide students with consistency throughout the semester. Ultimately, the unit coordinator had to remove aspects of ARS from that unit as the inconsistency "actually caused a bit of uproar amongst students". The instructor continued: "I was the main coordinator. I taught about 60% ... the one teaching 40% did not want to use it. So I had to stop".

C. Sustained Use and Pedagogical Beliefs

Time was perhaps the single most prominent theme in each of the individual interviews. Each of the instructors expressed a desire to improve their teaching but found this difficult to balance with their research and other commitments. This scarcity of time appeared to result in instructors deciding to remove ARS which were then rationalized through pedagogical beliefs of what was most important to student learning.

One common thread was that spending time in class on ARS took time away from disseminating content in what was perceived to be an already full schedule. It should be noted that the argument for didactic content dissemination is not well supported. Active approaches involving ARS have been found to be a more effective way to teach [15]. Nevertheless, one instructor commented:

“I pepper lectures with stories and history and stuff to kind of keep it interesting. I would have had to have taken those out in order to put in ARS”.

Contrasting this with a continuing user discussing how they facilitate active learning, the difference in pedagogical beliefs are clear: *“They’re not black and white options and I do that on purpose because they’re worth discussing”.* Here, there was a clear focus on active learning which indicated a strong desire to follow sound pedagogical theory [14].

Another central issue of “time” was the perception that integrating an ARS tool in classroom teaching would take more time to do than instructors had available. This appeared to have two facets: the anxiety around adding to an already high workload and the impression that learning and using a new technology effectively would take a lot of time. The survey data supported the general idea that instructors had concerns around the overall time-overheads related to using ARSs (Fig. 3).

Intriguingly, although the survey respondents expressed these concerns, a similar number of respondents indicated that they “would have enough time to create ARS questions” for their lectures (Fig. 4). This may indicate that other time related factors, besides creating questions, are of more concern. Indeed, this was expressed succinctly in one of the interviews:

“... it was a little bit difficult for me to run it during a standard lecture, because of the time commitment, and it was just, I call it real estate, but it’s time, it’s so valuable. It was time in setting up, time in getting the class involved, time in getting the class, once you are done, getting them back into the class, all that was, it almost felt five minutes per question. When classes started, I had two classes, and all of a sudden I had lost 10 minutes in a 45 minute lecture. But meanwhile, one little question that you wanted to spend a minute on, has taken five. So, there is just not enough class time.”

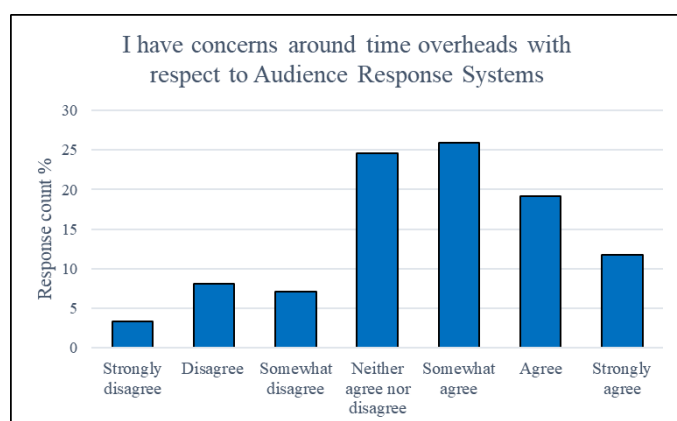


Fig. 3. 7-point Likert scale responses to the question “I have concerns around time overheads with respect to Audience Response Systems”.

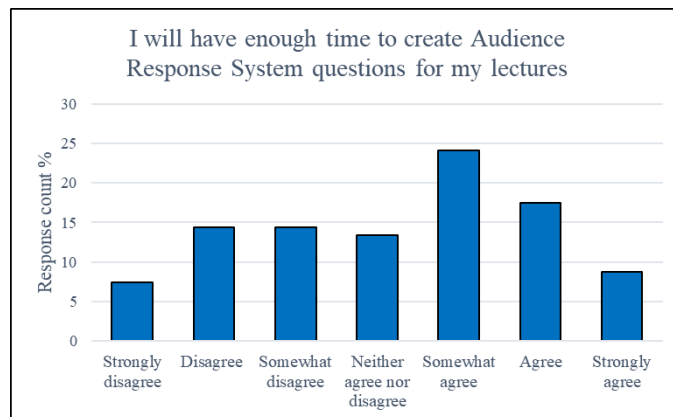


Fig. 4. 7-point Likert scale responses to the question “I will have enough time to create Audience Response System questions for my lectures”.

Time, however, was not only mentioned with respect to barriers but also with respect to *enabling factors*. One instructor commented:

“There’s one other benefit that does matter these days, given how little time we have and that is that the grading is done automatically. For me, I replaced an assignment and so fair enough, I had to spend the time, write the questions, do all of this, but now I don’t have to grade assignments. The students are happy as well because they get immediate feedback on whether their answers are correct and so it really suits everybody.”

It should be stated that using an ARS for assessment in this way may not necessarily be a simple thing to do. One survey participant cited the bureaucracy around submitting paperwork and receiving approvals to change assessment as “requiring a lot of planning” and therefore they were unable to transition to using ARS for assessment in as timely a manner as they had hoped.

“I couldn’t turn around and say, you know what? I want to reduce the amount in the final and put it all in the ARS, I mean you can’t do that. That requires signatures all the way up the chain”.

D. Sustained Use and Knowledge

Knowledge of the pedagogical methods to facilitate student learning was revealed to be a less commonly mentioned but important factor for sustained use. One instructor stated:

“I intended to do it probably once a week, but I didn’t think it got us anywhere better than not using it, so I left it for a bit more future thought. Not to abandon completely, but just that that way that I used it didn’t work.”

The same instructor continued:

“I think it would get better if I and the students were more familiar with actually using it. So probably with a bit of practice, actually, that would improve. But the thing that I probably just need a bit of guidance on, is structuring the question so that you get people to think about what you want them to think about. But also give some clear way for them to answer one thing or another.”

I think there's probably quite a skill in getting that (exactly what you ask) right."

Another instructor expressed the need to establish a platform that compiles the many different uses of ARS, and the best practices of ARS based on instructor's experiences. This would eliminate the need for instructors to experiment with different approaches, especially during valuable class time. As an example, an instructor trialed an open word-cloud feature of an ARS which involves students submitting key words of a related topic. At first, the instructor allowed students to submit a sentence. However, the tool was not effective as responses were too lengthy. Therefore, subsequent attempts limited the word cloud to accept only two words, and ultimately a single word. An additional issue was that students kept submitting amusing words which provided entertainment but had no relevance to the subject matter. The following quote accurately summarizes the issue of improper ARS use:

"Because the danger here is, if people use it, they don't use it properly and then say that it's not good, right. And then they actually miss out on the potential of this system".

Thus, improper use of the tool or using an unsuitable feature of the tool may detract instructors from sustained use.

Ultimately, it appears that instructors may abandon an ARS if they have a limited understanding of the tool that prevents them from using it efficiently or effectively. As an example, one ARS widely adopted at the institution allows instructors to navigate between polls from the results screen. Not being able to recognize this feature would require instructors to unnecessarily spend time returning to the home screen and browsing to the desired poll. Another instructor commented that the ARS revealed the responses by default, which influences the students' answers. Students may begin to blindly choose the most popular answer, which defeats the purpose of gauging student understanding. The instructor had not realized that there was a toggle to show or hide the live responses. Thus, the lack of the knowledge with respect to using the tool appeared to be a serious barrier for sustained use, especially if the intent of using an ARS was for assessment purposes.

E. Sustained Use and Self-efficacy

As mentioned previously in Section A, a few instructors cited technology concerns as barriers to initial adoption, particularly the reliability of network infrastructure on campuses, however, this was not found to be a reason for anyone to discontinue use. Rather the themes relating to self-efficacy were a loss of confidence (closely tied to the knowledge factors mentioned in Section D) and a sense of autonomy with respect to the direction of the unit.

The lack of pedagogical knowledge with respect to best practice was a clear barrier for sustained use in the case of one instructor. They stated:

"When I started, at the beginning of the semester, I planned to use it once a week, and I was hoping to use it more, but my first three times, I just found that losing the class focus was a major issue, so I stopped using it."

For this instructor, it was found that, without the appropriate pedagogical techniques to facilitate meaningful engagement, the value of ARS was lost.

Lack of agency in directing the pedagogical approach of a unit was also cited as a factor for not expanding use of ARS to assessment.

"...if I had had a choice, I would definitely have preferred to take points from the final [exam] and put it into a formal ARS. If I had that option I would have."

This may also be related to cultural factors such as the hierarchy of unit coordination duties, historical factors, interpersonal relationships or teaching experience. This lack of agency can even lead to apathy, *"Well, I am a part timer, I am not going to spend the time to flip a class that's not mine"*.

There was also a fear of the unknown: *"I just didn't have the time to do something that is relatively new and unexplored and replace my strength with that"*. In this case the instructor's strength was peppering traditional lectures with history. *"What I didn't want to do was give up the history for ARS because it's trading something that's a strength for something that is an unknown"*.

There is some evidence to suggest that most of these barriers can be addressed through cultural enablers. An instructor mentioned that observing the use of an ARS in practice helped them understand how they could be used to successfully achieve learning outcomes. Furthermore, *"... if you teach someone how to use this, without that person actually seeing it being used in class, it's difficult to... it's very intimidating sometimes"*.

F. Future Opportunities

Identification and understanding of the motivating factors and barriers for sustained use of ARSs by individual academics in our institution has provided crucial insight into the remaining barriers to sustained use and will lead to the development of new strategies for improving ARS awareness and the promotion of its benefits and feasibility.

The four key variables of the framework are summarized as follows:

Enablers/Barriers of Sustained Use

Culture

Peer pressure may cause instructors to continue using ARS in order to keep pace with the institution's instructional practices.

Conversely, a negative attitude towards ARS from co-instructors can cause sustained users to discontinue use.

Pedagogical beliefs

Time scarcity causes instructors to make trade-offs in their lectures. This causes instructors to fall back on traditional approaches which appear to be rationalized through adjusted pedagogical beliefs.

Knowledge Lack of knowledge with respect to best practice can result in discontinued use when there is mismatch between expectations and outcomes. This was found to be related to different levels of self-efficacy among ARS users.

Self-efficacy Initial fears of ARS not being useful were not allayed after initial use causing a lack of confidence to achieve the desired learning outcomes through ARS. This was found to be closely linked to lack of pedagogical knowledge.

In addition to informing culture change throughout the faculty, these findings will also be used to inform the design of our bespoke ARS tool which, due to previous research of this nature, has ten times more users at the university than the industry standard option (also available to instructors at the university).

IV. CONCLUSIONS

With respect to initial adoption, interview data indicated that cultural factors played the most significant role out of the four key variables. While instructors responding to the survey tended to say that “students” would be the primary reason they would adopt an ARS, in fact, exposure and encouragement from colleagues was the primary driver of initial uptake.

Enablers and barriers to sustained use were far more varied, however, primarily consisted of cultural factors and pedagogical beliefs with some interplay between self-efficacy and knowledge-based factors. Of all the themes, “time” was found to be one of the most significant barriers with instructors citing the difficulties between running ARS questions and balancing other commitments such as “delivering the content”. Cultural factors were found to be both enablers (e.g. peer pressure to maintain a standard of teaching) and barriers (e.g. not getting “buy-in” from co-lecturers).

A fear of technology and self-efficacy have been the focus of a great deal of technology adoption research, however, these were found to be minimal barriers to the *sustained* use of ARS. It may be that these factors are of more concern for initial adoption rather than sustained use. Nevertheless, there were some concerns around being able to ensure all students had an appropriate device and internet access.

Finally, knowledge factors were found to play a small but significant role in preventing sustained use. More concretely, lack of pedagogical knowledge led to less than optimal experiences with ARS which impacted the instructor’s self-efficacy.

Identifying the barriers and enablers to the sustained use of ARSs will allow us to improve the design of strategies for increasing ARS awareness, develop custom software to facilitate usage based around these principles and continue the promotion of ARS benefits and feasibility.

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