iLEARN Evaluation Report

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TECHNOLOGY CENTRE
Learning Innovation
AN ENTERPRISE IRELAND & IDA IRELAND INITIATIVE

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1 The Learnovate iLearn Team

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UCD - **SSR:** Brian Cunningham, Houssem Jerbi , Michael O'Mahony, , Markus Schaal, Lei Zhang

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TSSG - Data Capture: Dominic Maguire

Thanks to Ian O'Keeffe and Peter Gillis who assisted with the smooth running of the trial. Thanks to Intel, Learnovate's industry partner who supplied the devices for the trial.

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2 Executive Summary

Problem solving and collaboration have been identified as key 21st century workforce skills but there is uncertainty amongst trainers and educators as to leverage technology to develop and assess these complex skills. iLearn is an immersive learning environment (ILE) designed to develop and assess problem solving and collaboration skills through task-based learning. Through iLearn, Learnovate investigated the affordances of immersive learning environments for the development and assessment of problem solving and collaboration skills.

The iLearn trial delivered on its objectives to establish the engagement value and effectiveness of iLearn demonstrator for task-based problem solving, to establish whether iLearn could elicit and capture evidence of problem solving and collaborative behaviours and to determine the effectiveness of iLearn for teaching and learning.

Task completion rates were high reflecting participants' engagement with the immersive learning environment itself and the motivational effect of game mechanics that were integrated into the task design. High levels of participant engagement with the task enabled the successful elicitation of behaviours associated with problem solving and collaboration. The high rate of task completion ensured the successful end-to-end capture of indicators associated with those behaviours for analysis and evaluation highlighting the potential of iLearn as a stealth assessment tool.

In terms of learning effectiveness, average learning gains of 29% were recorded when the results of Pre-Trial Tests were compared with Post-Trial Tests. The potential of iLearn as a teaching/training tool was demonstrated during the trial. During the trial, class teachers could enter iLearn as a Pedagogical Agent to provide personalised, point-of-need scaffolding to participants requiring support as they progressed through the problem solving task. From the 'Teacher House', the teacher could unobtrusively observe the real-time progress of each participant by observing their corresponding meter on the wall of the teacher house. The teacher could also monitor Chat exchanges by looking at real-time data in emanating from the world and send Chat messages to participants who appeared as though they were having trouble and teleport to them to provide more targeted assistance if necessary. Participants who received at least one Chat message from the Pedagogical Agent were found to be more successful in solving the problem. Teachers indicated that they enjoyed being a Pedagogical Agent in iLearn because they could monitor problem solving and collaborative activity in real time and spot difficulties as they arose.

The results of the iLearn trial indicate that the iLearn immersive learning environment has potential for the teaching, learning and assessment of complex 21st century skills such as problem solving and collaboration in an education context. It provides a new paradigm for the teaching, learning and assessment of complex 21st century skills.

An obvious next step for Learnovate would be to partner with a Learnovate member to evaluate iLearn in a corporate setting with a different cohort of participants to establish whether the affordances identified in an education context can be reproduced in a workplace context using an authentic workplace task. If the results are reproducible, iLearn would have implications for how organisations recruit employees for specific skillsets, train and assess employees, manage their performance and development and identify competencies within their workforce. Furthermore,

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building on the iLearn task, the authentic workplace task could be extended to elicit behaviours associated with other complex 21st century skills such as decision making and critical thinking.

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3 Background to the iLearn Trial

Research shows that Immersive Learning Environments (ILEs) such as Virtual Worlds engage learners and are useful for open-ended exploratory learning. However, their potential for task-based, problem solving remains unclear.

iLearn is an immersive learning environment (ILE) designed to develop and assess problem solving and collaboration skills through task-based learning. Problem solving and collaboration have been identified as key 21st century workforce skills but there is uncertainty amongst trainers and educators as to how to leverage technology to develop and assess these complex skills. Through iLearn, Learnovate is investigating the teaching, learning and assessment affordances of immersive learning environments for the development and assessment of problem solving and collaboration skills.

The iLearn **Learning Task** provides a structured pedagogical framework to elicit problem solving and collaborative behaviours within the immersive learning environment. The learning task was designed to elicit explicit indicators of problem solving and collaboration activity. The indicators of problem solving and collaboration activity were clearly defined in the context of the iLearn task. In iLearn, evidence of problem solving and collaboration activity is captured from a number of sources within the learning environment to enable data triangulation. Incorporated into the task design are game mechanics to motivate learners to complete the task.

To implement the pedagogical framework, iLearn comprises a number of component technologies – the immersive learning environment itself (ILE), social search and recommender technology (SSR) and data capture technology.

The **ILE** was designed to enable learners to perform the task and to capture specified indicators of problem solving and collaboration activity within the context of the task. The engagement affordances of the immersive learning environment (together with the game mechanics interwoven into the Learning Task) were exploited to engage and motivate learners to complete the task so that the behaviours could successfully be captured from beginning to end.

The **SSR** acts as a conduit for problem solving and collaboration activity in iLearn (searching, voting and tagging). It also captures evidence of collaboration activity (manifested through voting and tagging).

Data Capture technology is integrated into iLearn to capture the indicators of problem solving and collaboration activity within the ILE.

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4 The iLearn Trial

4.1 Overview

The iLearn trial took place in the Learnovate Centre, Trinity College Dublin, during February and March 2014. 109 Transition Year students, aged between 15 and 17 from four Dublin schools took part in the trial. There were seven trial sessions in total - February 28th, March 3rd, March 4th, March 10th, March 11th, March 13th and March 14th.

The high specification devices which helped optimise the trial of the iLearn immersive learning environment were supplied by Intel - a Learnovate industry member and the 'Industry Champion' for the iLearn project.

4.2 iLearn Trial Objectives

To determine:

1. whether iLearn could effectively engage participants in task-based problem solving and collaboration
2. the effectiveness of iLearn to elicit and capture collaboration behaviours
3. the effectiveness of iLearn to elicit and capture problem solving behaviours
4. the effectiveness of iLearn to elicit and capture collaborative problem-solving behaviours
5. the effectiveness of iLearn for teaching and learning
6. the impact of the Recommender in iLearn: Test Group (+Recommender), Control group (-Recommender)

4.3 iLearn Trial Participants

109 Transition Year students, aged between 15 and 17 from 4 Dublin schools took part in the trial. The schools were selected to ensure a broad demographic and ability spread and also to reflect a gender spread. Based on random assignment of unique identifiers, each teacher assigned participants to either the Test Group or the Control Group.

4.4 iLearn Trial Methodology

4.4.1 Pre-Trial

Learnovate provided the teacher with a class briefing document that requested the teacher to lead the trial group in a discussion about the potential benefits of collaborating when solving problems and the usefulness of recommender systems such as Amazon, Facebook, YouTube and Netflix. The briefing document also provided the teacher with a description of what the trial participants would be required to do during the trial and requested that it be explained to them. In addition, Learnovate provided the teacher with a short Pre-Trial Test to be delivered to the participants in advance of the trial. Each teacher was supplied with a set of unique identifiers and was requested to randomly assign one to each trial participant.

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4.4.2 Day of Trial

4.4.2.1 Practice Session

An initial briefing session was followed by a practice session on the Training Island area of iLearn. This enabled participants to acquire and practice the skills they would need later to carry out the task in iLearn and also to familiarise themselves with the ILE.

4.4.2.2 Trial Session

Participants were requested to wear headphones. All communication with team members during the problem solving task was to take place via in-world Chat (so that it could be captured as part of the research). The teacher Once participants had completed the task and logged out of iLearn, they were asked to complete an online survey – the Post-Trial Qualitative Survey.

The teacher could enter iLearn as a 'Pedagogical Agent' who was on hand to provide scaffolding if requested by the participant. From the 'Teacher House', the teacher could also unobtrusively observe the progress and behaviours of each of the participants as they progressed through the task.

4.4.3 Post-Trial

Learnovate provided the teacher with Post-Trial Test to be administered to the participants within a few days of having completed the trial.

4.5 The Task

Each team was required to improve the overall energy usage of Eco Street. Each member of the team was assigned their own house on the street which they had to improve and in doing so; contribute to improving the overall energy usage of the Eco Street. While improving the energy usage of their own house members of the team were required to collaborate with each other for the good of the team. There were two methods through which team members could collaborate. One was voting and tagging useful resources they found using Search Boxes located beside problem areas so that the useful information would be recommended to other team members. The second method of collaboration available to the team was through in-world Chat. Each team member was required to 'fix' 3 problem areas of their own house while staying within a budget and to vote and tag 5 resources for each of the selected problem areas in their house. Having selected the problem areas of the house to be 'fixed', team members could buy replacement items in the SuperStore on Eco Street and check the impact of their purchase on energy usage using the house meter. Having completed the task in their own house, team members could meet up at the Team Scoreboard to view the overall improvement in energy usage of Eco Street. 'Fixing' 3 problem areas of their own house while staying within a budget could earn each team member a gold or silver medal and voting and tagging 5 resources for each of the selected problem areas in their house could earn each team member a collaboration badge. Any medals or badges earned by team members were also displayed on the Team Scoreboard. Gold or Silver medals indicated that a team member completed the task while staying within budget. Bronze medals indicated that a team member had completed the task but went over budget. A collaboration badge was awarded is a team member voted on and tagged 5 resources for each of their selected 3 problem areas.

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5 iLearn Trial Results

5.1 Evaluation of iLearn for Learner Engagement

Trial objective 1: To determine whether iLearn can effectively engage participants in task-based problem solving and collaboration

Evidence of learner engagement with iLearn came from multiple sources to enable triangulation of data:

1. **In-world**: activity in the immersive learning environment, interaction with SSR, in-world Chat
2. **Post-Trial:** Qualitative Survey

5.1.1 In-world indicators of learner engagement

- **Activity in the immersive learning environment:** A medal indicates task completion by a participant
- **Interaction with the SSR:** A collaboration badge indicates a participant has voted on and tagged the required number of resources in the SSR
- **Chat** (articulations indicating engagement with the task)

5.1.1.1 Activity in the immersive learning environment

79% (86) of the 109 participants who started the task completed the task i.e. replaced 3 energy inefficient items in their house. Participants who completed the task received a medal.

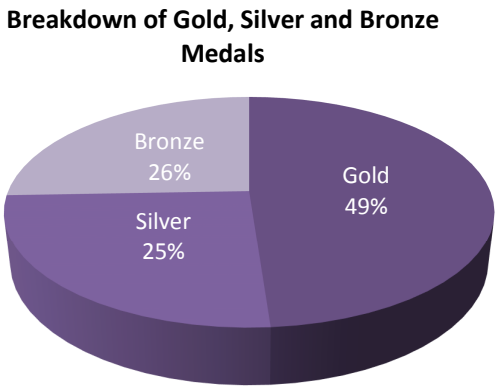

Figure 1: Task completion indicator

Of the 79% who completed the task, the medal type breakdown was 26% Bronze (completed the task but went over budget), 25% Silver and 49% Gold (these groups had different degrees of success in completing the task while staying within budget.

5.1.1.2 Interaction with SSR

Participants who voted on and tagged 5 resources for each of 3 problem areas in their house were awarded a Collaboration Badge. In the trial, **51%** (56) of 109 participants who started the task were awarded a Collaboration Badge.

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5.1.1.3 *Chat Indicators of Task Engagement*

105 of the 109 participants engaged in in-world Chat. Of those 105, **80%** engaged in task-related chat i.e. made Collaborative Articulations and/or Problem Solving Articulations.

"This kid is buzzing"	"Much excitement"
"It's super!"	"So much fun"
"This is fun"	"Like I'm on Bebo"
"This is deadly"	"Wonderful"
"Brilliant!!"	"This is interesting"

Figure 2: Chat indicators of engagement with iLearn

5.1.1.4 *Cumulative in-world indicators of Task Engagement*

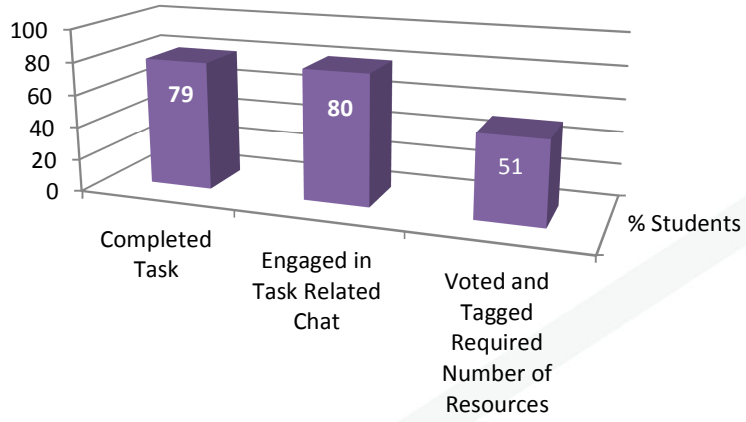

Figure 3: Cumulative in-world indicators of learner engagement

Evidence of learner engagement came from a number of sources within the learning environment and indicates overall that learner engagement was high. The lower value, 51%, relating to voting and tagging the required number of resources, will be discussed in detail in the following section.

5.1.2 Post-Trial Qualitative Survey

After the participants had completed the task in iLearn and logged out of the ILE, they were requested to complete an online survey to enable the Learnovate researchers to gather qualitative feedback on the iLearn experience.

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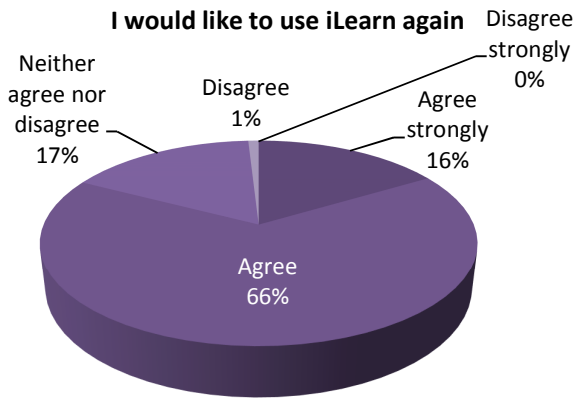

Figure 4: Qualitative Survey feedback

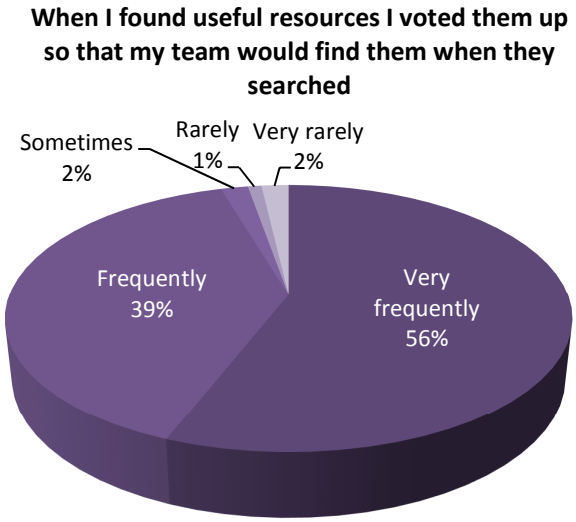

Figure 5: Qualitative Survey feedback

5.2 Evaluation of iLearn for Collaboration

Trial objective 2: To determine the effectiveness of iLearn to elicit and capture collaborative behaviours.

Evidence of collaboration in iLearn comes from multiple sources to enable triangulation of data:

1. **In-world:** interaction with SSR, receipt of a collaboration badge, in-world Chat
2. **Post-Trial**: Qualitative Survey

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5.2.1 In-world indicators of collaboration

- **SSR Activity** (voting and tagging)
- **Collaboration Badge**
- **Chat** (articulations indicating collaboration)

5.2.1.1 SSR Activity - Voting and Tagging

The average number of votes and tags per participant was higher than expected. In total participants were required to vote on **15** resources (5 per each of 3 selected problem areas) and tag 15 resources (5 per each of 3 selected problem areas). However many participants went beyond what was expected of them. This was unexpected and would indicate engagement with the task coupled with the motivation to achieve a Collaboration badge.

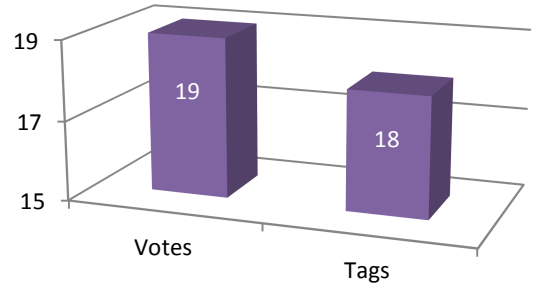

Figure 4: Average votes and tags per participant

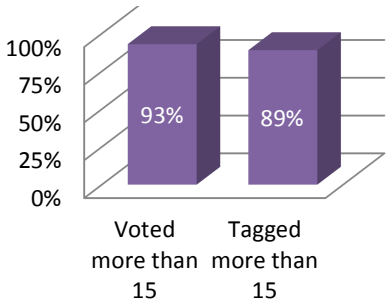

Figure 5: Percentage of participants voting and tagging more than 15

5.2.1.2 Collaboration Badge

Participants who voted on and tagged 5 resources for each of 3 problem areas in their house were awarded a Collaboration Badge. In the trial, **51%** (56) of 109 participants who started the task were awarded a Collaboration Badge. Given that 93% of participants voted on 15 or more resources and 89% of participants tagged 15 or more resources, the number of Collaboration Badges is lower than expected. It is also somewhat out of keeping with the other engagement indicators represented in *Fig: 2*. However, from Chat analysis and also from some comments made during Post-Trial Debriefing Sessions, it is clear that the requirement for participants to vote on **and** tag 5 resources for each of 3 problem areas proved too onerous and was, in some cases, perceived as a barrier to completing the

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task. Some participants therefore did not complete all of the required SSR activities be awarded a Collaboration Badge.

Were participants more likely to get a Collaboration badge if they had access to the SSR? The results would appear to indicate not as the Control Group (-SSR) earned more Collaboration Badges than the Test Group (Fig. 7).

Was there a correlation between getting a collaboration badge and successfully completing the task? The data indicates there was (Fig.6). Participants who successfully the task, were awarded either a gold or silver medal depending on how well they improved the energy usage of their house. From the data we see that this group earned a higher number of Collaboration Badges than the bronze medal group who completed the task but failed to stay within budget.

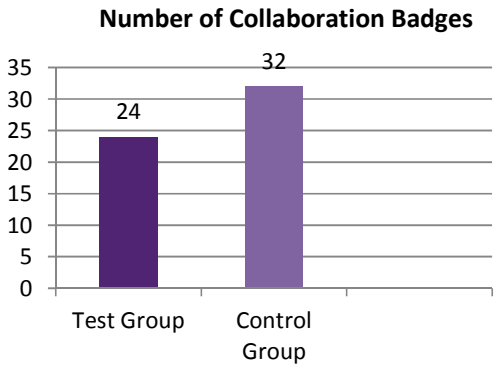

Figure 7: Comparison of collaboration badges achieved by Test and Control groups

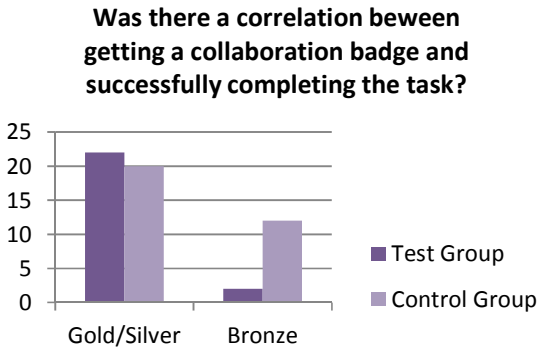

Figure 6: **Medals obtained by participants who got a Collaboration Badge**

5.2.1.3 Chat indicators of collaboration

"Need any help?"

"id advice you to go for lighting"

"don't forget to tag and vote on 5 things"

"dont get liquid crystal windows"

"Tag it to me"

Figure 8: Chat indicators of collaboration

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105 participants of the 109 engaged with Chat. Of those **72%** (76) made collaborative articulations. The number of collaborative articulations was greater than expected. It was anticipated that the bulk of the Chat articulations would be 'social' in nature but this was not the case again indicating focus and engagement with the task. Collaborative articulations were made by participants across the demographic, ability and gender spread. One of the more interesting collaborative articulations was *"Tag it to me"* which most likely reflected the participants' real-world use of social media such as Facebook where tagging results in a message being sent to relevant people.

5.2.2 Post-Trial Qualitative Survey

After the participants had completed the task in iLearn and logged out of the ILE, they were requested to complete an online survey to enable the Learnovate researchers to gather qualitative feedback on the iLearn experience.

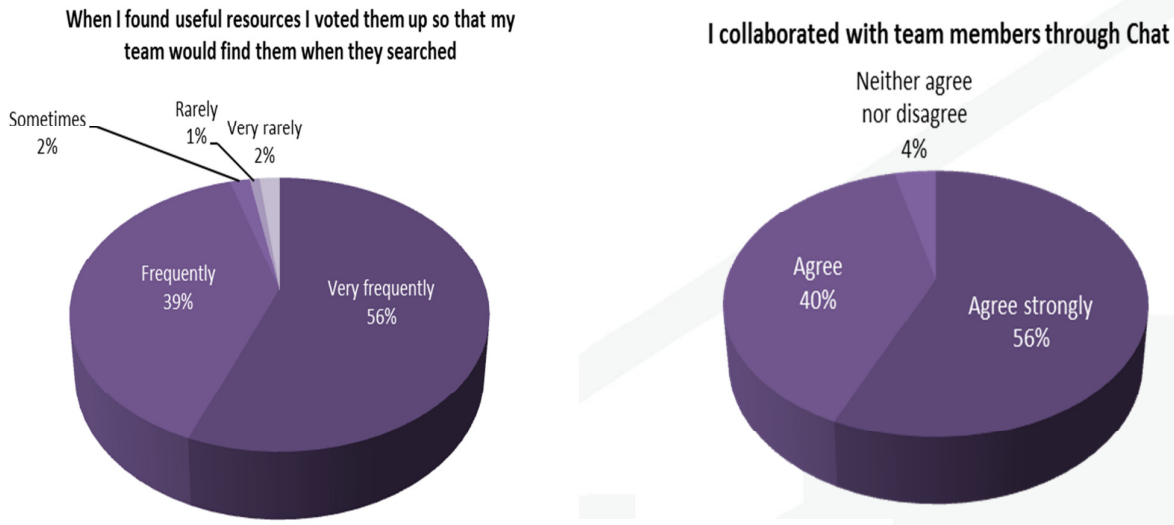

Figure 9: Qualitative Survey feedback

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5.3 Evaluation of iLearn for Problem Solving

Trial objective 3: To determine the effectiveness of iLearn to elicit and capture problem solving behaviours.

Evidence of problem solving in iLearn comes from multiple sources to enable triangulation of data:

- **In-world**: activity in the immersive learning environment, participant interaction with SSR, participant in-world Chat
- **Post-Trial**: Qualitative Survey

5.3.1 In-world indicators of problem solving

- **Medal** (identifies problem solvers, colour of medal indicates degree of success)
- **Problem solving activity** (checking meter, search activity using the SSR)
- **Chat** (articulations indicating problem solving)

5.3.1.1 Medal

Of the 86 participants who completed the task, **74%** (64) successfully solved the problem (replacing 3 energy inefficient items while staying within budget). Depending on how effectively these participants replaced the 3 items while staying within budget, they were awarded either gold or a silver medal - 42 participants were awarded a gold medal and 22 a silver medal. The remaining 22 participants who completed the task but failed to solve the problem (because they failed to stay within the budget) were awarded a bronze medal.

5.3.1.2 Problem solving activity

The problem solving task was designed to elicit behaviours associated with problem solving such as identifying the problem, searching for a solution, being discerning and selective and validating the selected strategy as part of arriving at the final solution. Below is some of the evidence captured from iLearn in terms of problem-solving behaviours. As part of the evaluation, the problem solving activity of the successful problem solvers (recipients of gold/silver medals) was compared to the problem solving activity of the 'unsuccessful' problem solvers (recipients of bronze medals) to identify behaviours associated with successful problem solvers in the context of the iLearn task.

5.3.1.2.1 Searching for a solution

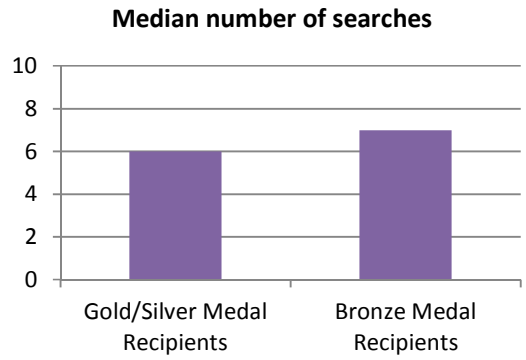

Figure 10: Correlating number of searches with medal types

5.3.1.2.2 Validating the selected problem solving strategy

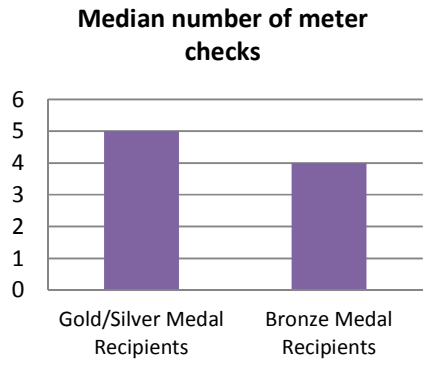

Figure 11: Correlating validation of approach with medal types

5.3.1.2.3 Chatting with others

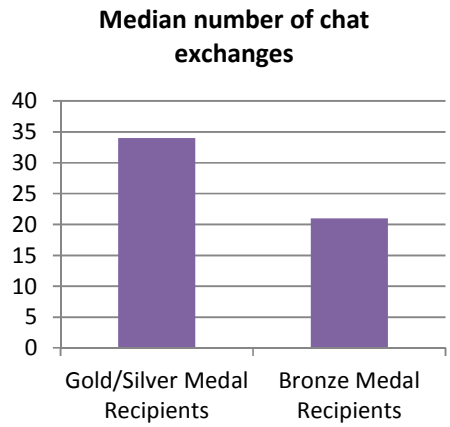

Figure 12: Correlating Chat with medal types

5.3.1.3 Chat indicators of problem solving

105 participants of the 109 engaged with Chat. Of those **55%** (58) made problem solving articulations. The number and quality of problem solving articulations was greater than expected. It was anticipated that the bulk of the Chat articulations would be 'social' in nature and that it would be rare to come across problem solving articulations but this was not the case. Problem solving articulations were made by participants across teams and across the demographic, ability and gender spread of the trial.

"are you doing ALL of the research and then ALL the buying or research, buy, research, buy"

"trying to see what the best buy is"

"i could probably spend a bit more money within my budget and go for an appliance that uses less kilowatts?"

Figure 13 Chat indicators of problem solving

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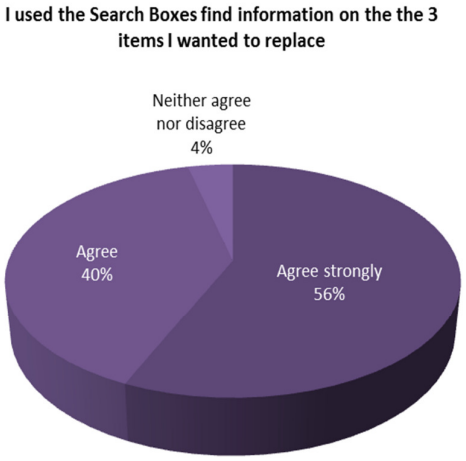
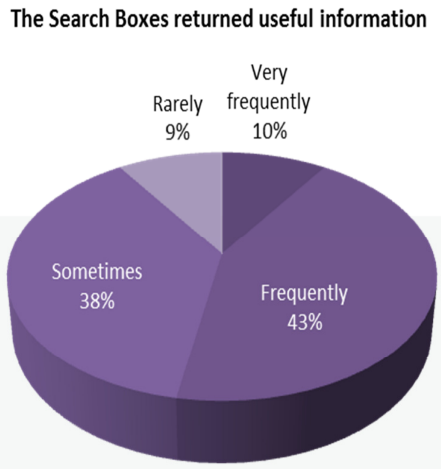
5.3.2 Post-Trial Qualitative Survey





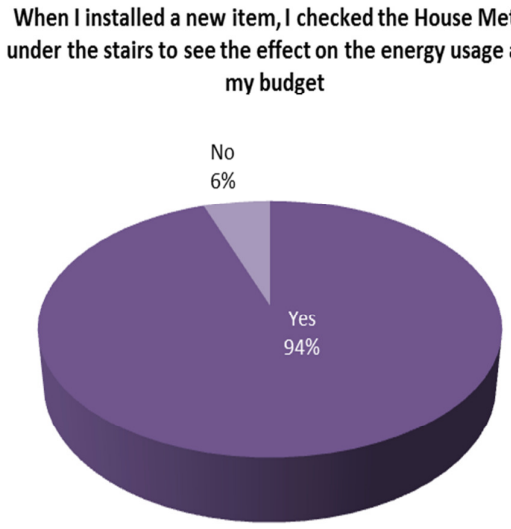


Figure 14: Qualitative Survey feedback

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5.4 Evaluation of iLearn for Collaborative Problem Solving

Trial Objective 4: To determine the effectiveness of iLearn to elicit and capture collaborative problem-solving behaviours.

Evidence of Collaborative Problem Solving comes from multiple sources to enable triangulation of data:

1. **In-world**: interaction with SSR, in-world Chat, activity in the immersive learning environment
2. **Post-Trial:** Qualitative Survey

5.4.1 In-world indicators of collaborative problem solving

- **Voting** and **Tagging** resources in SSR
- **Chat**
- Overall **improvement in energy usage of Eco Street** by the team (Team Scoreboard)

5.4.1.1 Voting and Tagging

There was a high level of voting and tagging indicating, in the context of the iLearn task, participants' willingness to collaborate with team members. This high level of voting and tagging, going beyond the 15 resources they were required to vote and tag, would also have been influenced by the motivation to earn a collaboration badge.

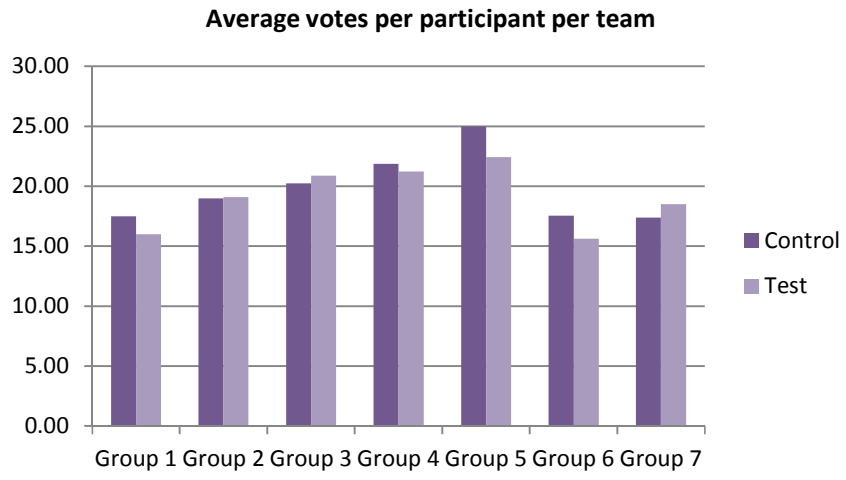

Figure 15: Average votes per participant per team

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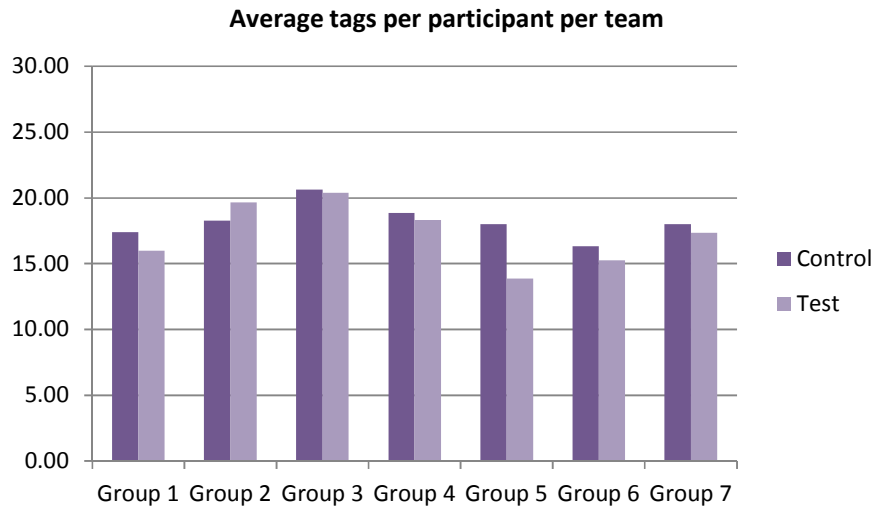

Figure 16: Average tags per participant per team

5.4.1.2 Chatting

105 participants of the 109 engaged with Chat. The number of task related articulations was greater than expected. It was anticipated that the bulk of the Chat articulations would be 'social' in nature and that it would be rare to come across task related articulations but this was not the case, task related articulations were the predominant exchanges during the course of the task . Collaborative problem solving articulations were made by participants across teams and across the demographic, ability and gender spread of the trial cohort.

"Which ones are we picking? Will I do insulation?"

"doing it for the team"

"I got the one at the end its silver has a high energy rating and wasnt too expensive"

"yeah. 4400, but check under the stairs it will tell you what you have left"

"come to the car park"

Figure 17: Chat indicators of collaborative problem solving

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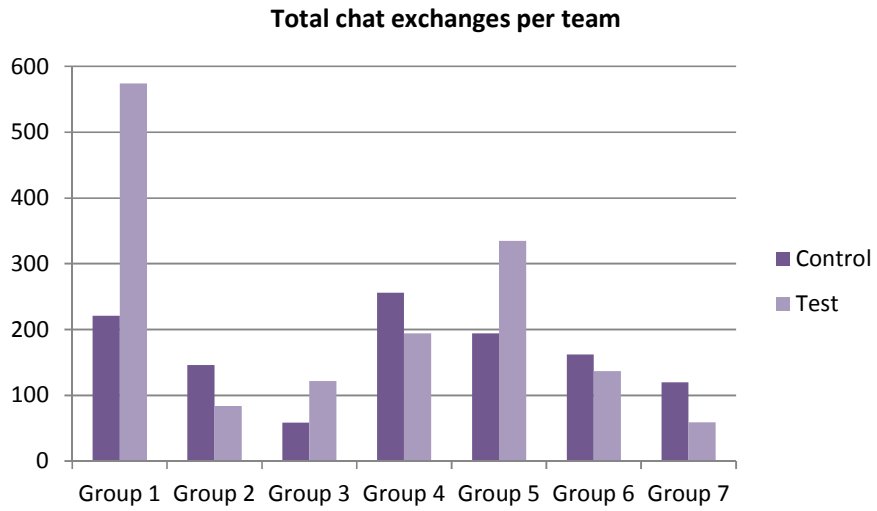

Figure 18: Total chat exchanges per team

5.4.1.3 Team Improvement in Energy Usage of Usage of Eco Street

In terms of successfully solving the problem, Group 3 (Control) together with Group4 (Test) achieved the best reduction in energy per unit cost. iLearn provides insight into the behaviours and best performing teams in terms of behaviours and dynamics.

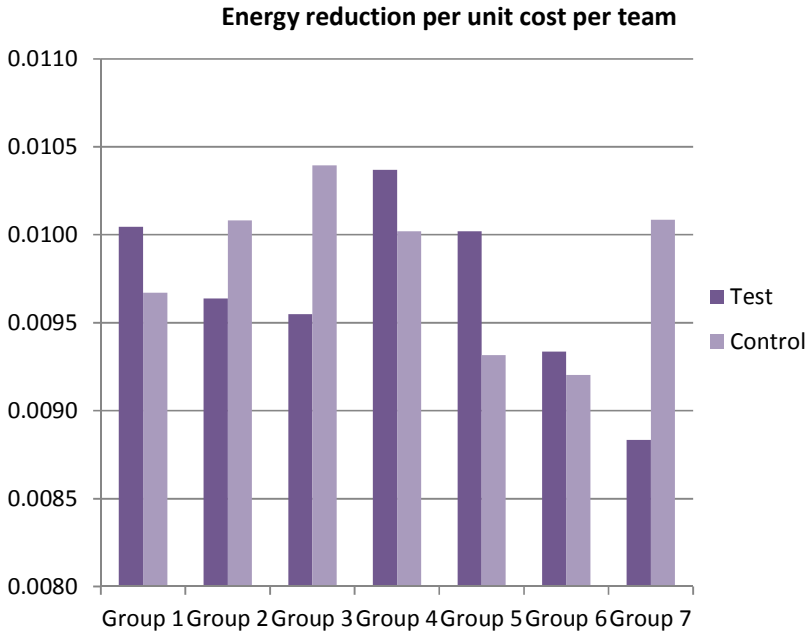

Figure 19: Energy reduction per unit cost per team

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Group 3 (Control) had 7 people on the team. 71% of the team achieved gold medals, 14% silver medals and 85% collaboration badges. 28% of the team made problem solving articulations and 28% of the team made collaborative articulations. On average each team member voted on 20 resources and tagged 20 resources. Group 3Control was an all-girls team.

Group 4 (Test) had 10 people on the team. 70% of the team achieved gold medals and 40% received collaboration badges. 70% of the team made problem solving articulations and 50% of the team made collaborative articulations. On average each team member voted on 21 resources and tagged 18 resources. Group 4Test was a mixed boys/girls team.

Two teams - two successful problem solving outcomes. However iLearn can provide us with insight the attributes and behaviours of the 'successful' teams. From in world chat logs and in world activity logs and we can see that Group 3 (Control) was highly systematic in its problem solving approach. It was a self-organising team with evidence of dividing out labour early in the task and providing fewer but more focussed articulations during the course of the task. There is also evidence that this team is competitive and driven. Group 4 (Test) achieved the same end-result but their approach to solving the problem was somewhat different. They were less overtly systematic in their approach and more creative. While they were much less organised in terms of dividing out labour, they were more social and collectively made more explicit problem solving articulations than the other team as they progressed through the task.

Across the trial, in terms of successfully solving the problem, there are not significant differences between the control group and the test group the control group. Where they do exist, it may be that there are strong influencers in a group who are contributing to the group's success through task-focussed chat.

5.4.2 Post-Trial Qualitative Survey Feedback

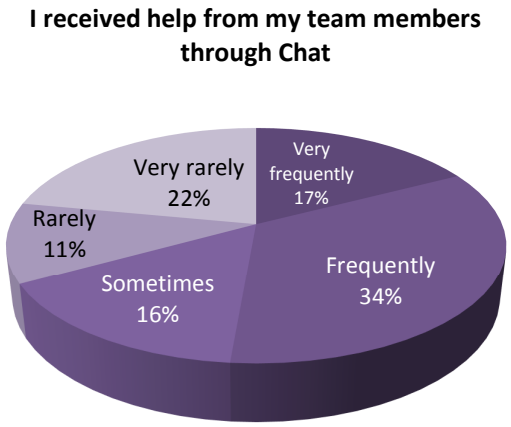

Figure 20: Qualitative Survey Feedback

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5.5 Evaluation of iLearn for Teaching and Learning Effectiveness

Trial Objective 5: To determine the effectiveness of iLearn for teaching and learning

5.5.1 Evaluation of iLearn for Teaching Effectiveness

The teacher could enter iLearn as a 'Pedagogical Agent' who was on hand to provide point-of-need scaffolding if requested by the participant. From the 'Teacher House', the teacher could unobtrusively observe the progress of each participant by looking at their corresponding meter on the wall of the teacher house (there was a meter for each of the participants). The teacher could also monitor Chat exchanges by looking at real-time data in emanating from the world. The teacher could also send Chat messages to participants who appeared as though they were having trouble and teleport to them to provide more targeted assistance.

Going into iLearn as a Pedagogical Agent during the trial was an option for all teachers who accompanied participants to Learnovate. All teachers eagerly embraced the challenge which meant that there was a pedagogical agent in iLearn for each trial session. Teachers quickly became proficient at monitoring participants and providing point-of-need support through Chat if requested.

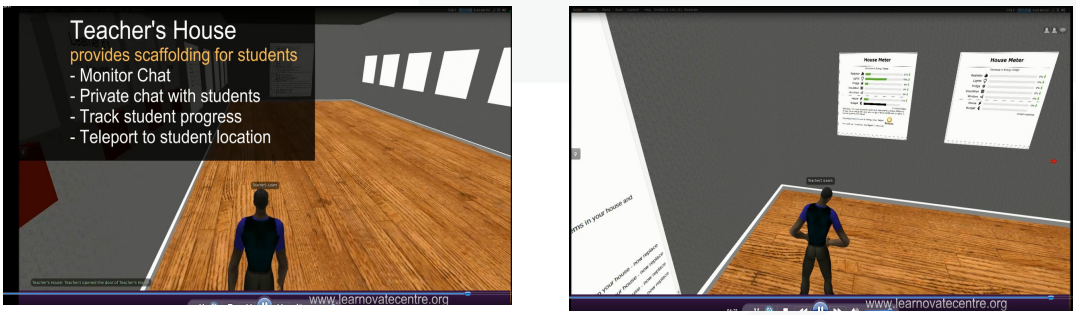

Figure 21: Pedagogical Agent in the Teacher House

An interesting research question was to establish whether participants who received point-of-need support from the Pedagogical Agent were more likely to receive gold or silver medals. Given that the number of Chat exchanges with the Pedagogical Agent was much lower than those with fellow team members, we anticipated that there would be little if any effect. However from the data we see that there is a correlation. Of those who had successfully solved the problem (achieved a gold or silver medal) the majority had received at least one Chat message from the Pedagogical Agent (Fig: 22)

Some examples of Chat messages from Pedagogical Agents were:

"make sure you are practising all the skills you will need for later!"
"WELL DONE! Our first gold badge of the day on Eco Street!!"
"Why don't you see what your team think?"
"well done ! great bit of research and great result"
"if you could change something now to get a gold badge - what would you change?"
"are you ok? i will go and stand outside of your house - ok?"

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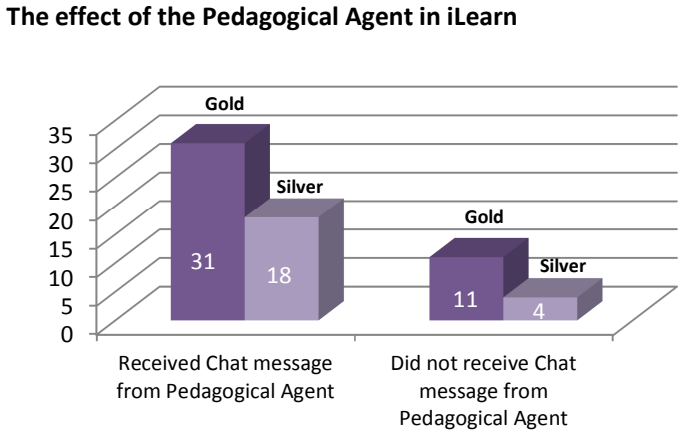

Figure 22: The effect of the Pedagogical Agent in iLearn

Teachers indicated that they enjoyed being a pedagogical agent in iLearn because they could monitor problem solving and collaborative activity as it happened and spot the problems as they arose. That way they felt that their interventions were more 'personal' and meaningful.

While the participants occasionally availed of the help of the pedagogical agent as they worked their way through the task, their enthusiasm for having the teacher present in the world was far less positive than the teacher's enthusiasm for being there.

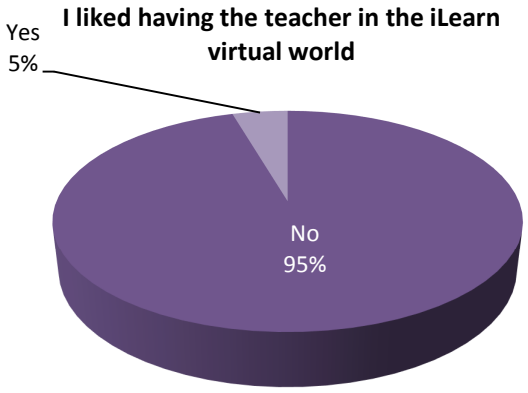

Figure 23: Qualitative Survey feedback

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5.5.2 Evaluation of iLearn for Learning Effectiveness

Comparison of Pre-Test and Post-Test results was used to evaluate knowledge gains resulting from use of iLearn. Teachers were requested to supervise the short Pre-Test which was to take place in the school immediately after the iLearn Teacher Briefing Session. The Teacher Briefing Session and Pre-Test took place in advance of the trial and the completed Pre-Tests were returned to Learnovate. Teachers were requested to have participants complete the Post-Trial Tests back at the school under supervision within a week of the trial. Ideally the Post-Trial Tests would have been administered in-situ immediately after the iLearn trial however, it was felt by both the teachers and the researchers that having completed the iLearn training session in the morning, the trial in the afternoon immediately followed by the online Post-trial Qualitative Survey that requiring the participants to then complete the Post-Trial Test was too onerous on the participants given their age.

Out of the 7 groups who took park in the trial, 5 groups returned the Post-Trial Test results. Of those 5 groups, 2 groups appear to have completed the Post-Trial Test under unsupervised conditions, and most likely at home. For reasons of test reliability, it was felt that the test results of these 2 groups should be discounted.

The Post-Trial Test results of the remaining 3 groups were compared with their Pre-Trial Test results. There was no significant difference between the Test and Control sub groups for each group. The average learning gain for the Test groups across the 3 groups was 29% and for the Control groups was 28%.

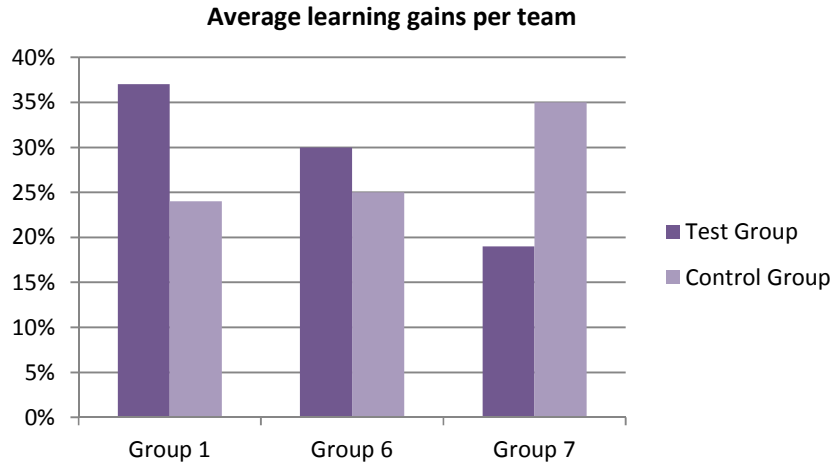

Figure 24: Average learning gains per team

Of interest is the way this graph mirrors the graph of the energy reduction per unit cost per team (Fig. 18 showing how effectively the teams solved the problem). Because this is a small sample size it is difficult to draw definitive conclusions but it appears that there may a correlation between what participants learned and how they applied it to solve the problem.

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Undoubtedly the selected game mechanics contributed to the high levels of learning task completion and to the high level of participant engagement. This was observed on the faces of the participants during the trial and reflected in the Post-Trial qualitative Survey feedback. Even though the sample size is small, it would also appear that the selected game mechanics achieved the dual pedagogical objective of achieving high task completion rates without compromising the learning effectiveness of the task.

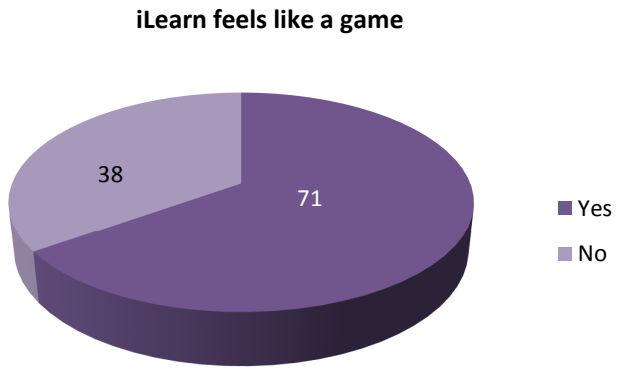

Figure 25: Post Trial Survey feedback

Figure 26: Participant immersed in the learning task

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6 The Impact of the Recommender Technology in iLearn

Trial objective 6: To determine the impact of the Recommender technology in iLearn

To implement the iLearn pedagogical framework, iLearn comprises a number of component technologies – the immersive learning environment itself (ILE), social search and recommender technology (SSR) and data capture technology.

From a pedagogical perspective, the SSR serves 3 purposes in iLearn; firstly it acts as one conduit for problem solving, enabling participants to search for and identify an effective solution to the problem and, in doing so, it elicits problem solving behaviours which can be captured by the system as evidence of problem solving competency. Secondly**,** the SSR itself captures evidence of collaboration activity manifested through voting and tagging. Thirdly, the Recommender element of the SSR facilitates problem solving by recommending resources which others have found useful in the context of the problem solving task. We will consider the impact of the recommender in the iLearn trial.

All trial participants had access to the search functionality of the SSR, while only the Test group participants received recommendations from the SSR. In response to a user search query, the search system returned standard search results (10 results per page). The user could scroll through 5 pages of results. Test group users were provided with an additional 3 results at the top of the first page of search results that were generated by the social recommender component (i.e. recommendations). Test group users could access to up to 10 recommendations by clicking on a specific link. Where the Recommender element of SSR was available (Test Group), participants selected on average, more results from the recommendations than from the standard search results.

6.1 Assisting participants to find useful information

The Recommender helped participants find useful information for the problem solving task - 73% of participants from the Test Group (compared to 53% of participants from the Control Group) indicated they found useful information when they searched (Figure 27a). Moreover, the availability of Recommender helped participants to find useful information more easily - 77% of participants from the Test group (compared to 59% from the Control group) indicated that they didn't have to search many times using different search terms to find useful information (Figure 27b).

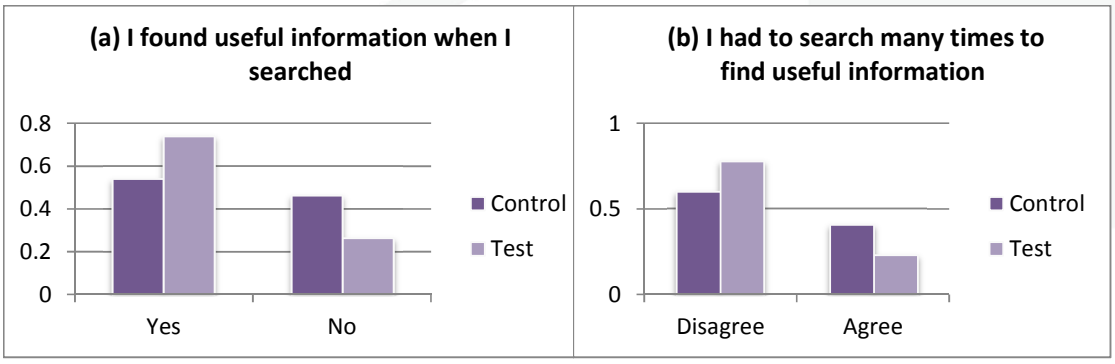

Figure 27a and 27b: Qualitative Survey feedback

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6.2 Comparison of SSR with in-world Chat

In iLearn, the SSR was one of two collaboration channels to support collaborative problem solving - the other being the in-world Chat component. Compared to using social search and recommendation for collaboration, in-world Chat is a much more familiar channel for communication and collaboration for this trial cohort. K-12 students are familiar with Instant messaging (e.g., Facebook chat, MSN Messenger, Google Talk, WhatsAp). When this is taken into consideration, the SSR performed well in terms of usage with 69% of users collaborating using in-world chat (i.e. either frequently or very frequently) compared to 50% through voting and 50% through tagging (Figure 28).

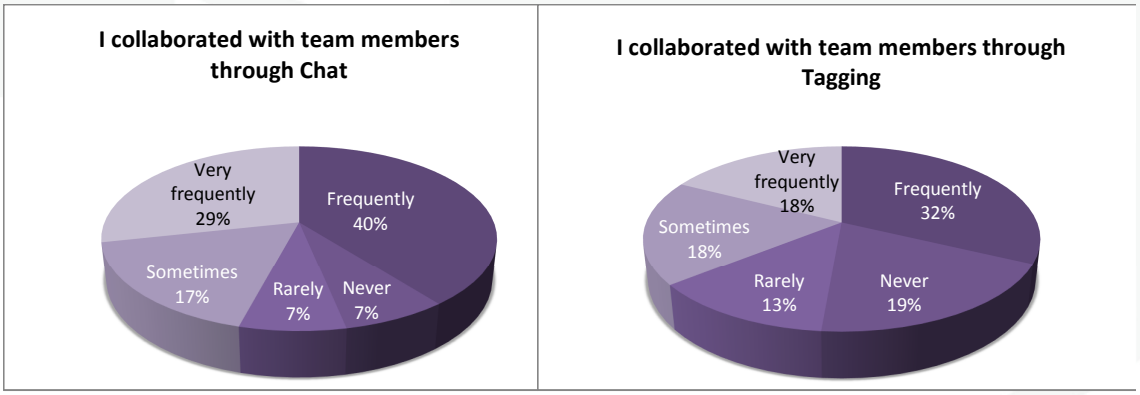

Figure 28: Qualitative Survey feedback

6.3 Comparison of Energy Improvement (Energy Usage per Unit Cost) of the Test and Control Groups

As part of the evaluation we considered whether participants with access to the Recommender (Test group) improved the energy usage of their house while staying within budget more effectively than participants without access to the Recommender (Control group). Comparing the energy improvement values (expressed as Energy Usage per Unit Cost) of the Control and Test groups over the whole trial, a *t*-test analysis indicates that statistically there is no significant difference between the performance of the Control group and the Test groups in relation to this metric (Figure 29, Figure 30). However further in-depth analysis is required to understand more fully the impact of the Recommender and its multiple affordances for collaborative problem solving tasks. For example, the relative effectiveness of the Recommender for weaker and stronger participants and also its effectiveness for varying levels of task complexity were not explored. While such investigations may prove significant in terms of determining the impact of the Recommender, they were beyond the research scope of the iLearn project.

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	Control Group	Test Group
Mean	0.41	0.40
Std.Dev.	0.08	0.06

Figure 29: Energy improvement (expressed in terms of energy usage per unit cost) of Test and Control Groups across the iLearn trial. A *t*-test indicated there was no statistically significance difference in results between the Test and Control Groups (*p*-value = 0.54).

6.4 Conclusion

The SSR successfully contributed to the elicitation and capturing of behavioural data relating to collaboration and problem-solving in iLearn. The Recommender element of the SSR also successfully assisted trial participants in finding useful information to help them solve the problem. While statistically, having access to the Recommender did not confer an advantage on the Test group in terms of an overall energy improvement, further in-depth analysis is required to understand the multiple affordances of the SSR for execution of the iLearn collaborative problem solving task.

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7 Evaluation of Usability of iLearn

A poorly designed learning environment can negatively impact learner engagement and learning outcomes. It was important that the usability of the iLearn immersive learning environment was sufficiently high to enable learners to focus on the task itself rather than become frustrated or distracted by the environment in which the task was executed. The learning environment must reflect and enable the pedagogical objectives of the task, be sufficiently authentic without being distracting and be intuitive in terms of navigation and orientation.

Evaluation of the usability of iLearn indicates that it has an overall SUS score of 68.14. This score is impressive for an immersive learning environment when compared to the usability of other immersive learning environments. Typical SUS scores for immersive learning environment range from 42 to 53 though there have been some reported cases where the SUS score is similar or higher than iLearn. However, in these cases, the variance in their scores has been up to 40 points whereas in ILearn is consistent throughout the trial.

To put this score in context, a score of 68 is the average score of a website. However, given that usability for website design is at a more advanced stage than usability design for immersive learning environments, this is a high SUS score.

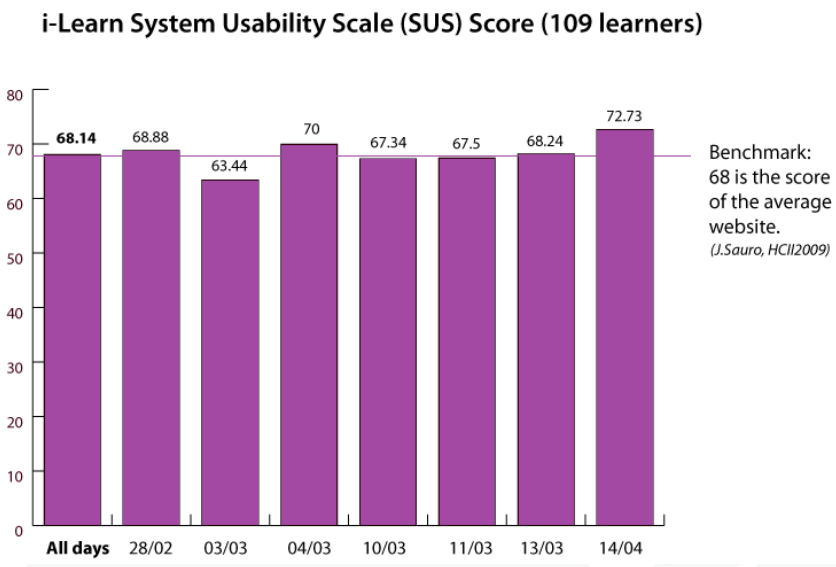

Figure 30: SUS score for iLearn

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8 Discussion of Results

Problem solving and collaboration have been identified as key 21st century workforce skills but there is uncertainty amongst trainers and educators as to leverage technology to develop and assess these complex skills. iLearn is an immersive learning environment (ILE) designed to develop and assess problem solving and collaboration skills through task-based learning. Through iLearn, Learnovate investigated the affordances of immersive learning environments for the development and assessment of problem solving and collaboration skills.

The iLearn Trial delivered on its objectives to establish the engagement value and effectiveness of iLearn for task-based problem solving, to establish whether iLearn could elicit and capture evidence of problem solving and collaborative behaviours and to determine the effectiveness of iLearn for teaching and learning.

Pivotal to the success of iLearn in delivering on its objectives was the learning task which provided a structured pedagogical framework to elicit problem solving and collaborative behaviours within the immersive learning environment. In iLearn, evidence of problem solving and collaboration activity is captured from a number of sources within the learning environment to enable data triangulation. Incorporated into the task design are game mechanics to motivate learners to complete the task.

The carefully selected game mechanics which were integrated into the task design were found to be powerful motivators for engagement with the problem solving task. The result was high rates of task completion which enabled the system to elicit and capture problem solving behaviours from beginning to end of the task. The task was designed to be sufficiently complex to elicit different types of problem solving behaviours and to discriminate between participants and this was reflected in the number of participants who completed the task successfully. The combination of high levels of participant engagement, high task completion rates and stealth assessment (concurrent learning and assessment to identify, develop and monitor complex 21st century skills such as problem solving) undoubtedly offers huge potential for corporate learning as well as education.

In solving the problem, participants were required to collaborate with their team members. There were two ways of collaborating in iLearn – one way was through voting and tagging the useful resources participants found when researching a solution using the Search Boxes and the other way was through in-world Chat. The number of participants voting on or tagging the required number of resources was much higher than expected and indicated a possible willingness to collaborate. However it may also have been influenced by the awarding of a Collaboration Badge for those who voted on *and* tagged 5 resources for each of 3 problem areas in the house. However the number of collaboration badges overall was lower than expected indicating perhaps that the overall requirement of voting and tagging was too onerous and acted as a perceived barrier to task completion. The purpose of the reward game mechanic in this case was not pedagogical but was in order to obtain a critical mass of voting and tagging for the recommender system to function effectively. An interesting outcome however was that there was a correlation between successful task completion and being awarded Collaboration badge with a higher number of participants who achieved a Collaboration Badge achieving gold or silver medals.

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Most participants embraced in-world Chat as a medium for communication and collaboration in iLearn. This enabled the capturing and identification of explicit collaborative behaviours, articulations and team dynamics. Once again this highlights the relevance of such systems for the corporate sector as well as educators in terms of identifying, monitoring, developing and assessing skills. One interesting finding surfaced through Chat was this trial cohort's (15-17 year olds) perception of tagging and recommending. Although all participants had engaged in a pre-trial discussion about the process, purpose and benefit of 'recommending' items in Amazon-like systems through voting and tagging, there was a an in-trial expectation that tagging would work as it does in Facebook. This is reflected in these Chat Log comments 'Tag it to me" followed by "I can't see it!" This trial cohort also displayed somewhat of a modality bias in terms of their collaboration channel, preferring in-world Chat to using social search and recommendation to recommend useful information to others. However this bias may not be reflected in a corporate cohort where recommending useful in-house documents and training resources to colleagues has both workplace efficiency benefits and career management benefits - highlighting the employee as a good collaborator and 'influencer' for career progression and talent management purposes.

iLearn surfaced interesting insights into collaborative problem solving at team level highlighting different, yet successful, problem solving strategies. Through discourse analysis it was also possible to identify contributors (team players) and takers – those motivated by personal gain rather than team goals. Once again this has corporate as well as educational application, enabling organisations to identify key competencies and informing project team selection and workforce planning.

Enabling the teacher to enter the immersive learning environment as a Pedagogical Agent during the trial enabled the evaluation of the effectiveness and potential of iLearn for teaching or training. Being on-hand to provide personalised, point-of-need support to participants who required it was highly valued by the teachers who took part in the trial. Having access, from the Teacher House, to real-time data on each student emanating from the immersive learning environment, enabled the teacher to follow the progress of the weaker students and to intervene where appropriate while monitoring the progress and encouraging of the rest of the group. Of interest is the finding that participants who received a Chat message of any description from the teacher were more successful at solving the problem solving.

Average learning gains of 29% were recorded when the results of Pre-Trial Tests were compared with Post-Trial Tests. This level of learning gain is impressive though not surprising given the level of engagement and focus of participants with the learning task. It is disappointing however that we did not have access to the full data set for various reasons outlined earlier. However, what is encouraging from a results point of view is that the 3 groups we analysed for learning gains represent a broad demographic, ability and gender spread.

Critical to the success of the iLearn trial, were the component iLearn technologies – the ILE, SSR and Data Capture technologies. They all performed as expected to elicit, enable and capture the behaviours associated with the collaborative problem solving task.

The impact of the SSR for collaboration, in the context of the iLearn task, was evaluated during the trial. The SSR (Social Search and Recommender) is designed to help users find relevant results (useful information, recommended by others to help them solve the task). It is clear from the post-trial

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survey that the SSR facilitated the learning task. For example, the Recommender helped participants find useful information for the problem solving task (73% of participants from the Test Group indicated they found useful information when they searched, compared to 53% from the control group) more easily (77% of participants from the Test group indicated that they didn't have to search many times using different search terms to find useful information, compared to 59% from the control group). Moreover, as shown in section 6, the recommender was widely accepted by the participants.

Given that participants could also collaborate via chat in iLearn, a more in-depth analysis is required to understand the dynamics of collaboration during the execution of the task which should shed further light on the impact of the SSR in general and more specifically, the Recommender.

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9 Conclusions and Recommendations

Learnovate's iLearn technology demonstrator has successfully addressed all of the iLearn project's research objectives outlined in the underpinning *iLearn Use Case*:

- to effectively engage participants in task-based problem solving and collaboration
- to elicit and capture collaboration behaviours
- to elicit and capture problem solving behaviours
- to elicit and capture collaborative problem-solving behaviours
- to determine the effectiveness of task-based immersive learning environments for the teaching and learning and assessment of complex 21st century skills
- to determine the impact of a Recommender in a task-based immersive learning environment

The results of the iLearn trial indicate that the iLearn immersive learning environment, the design of which is underpinned by a pedagogical framework for task-based learning, has considerable potential for the teaching, learning and assessment of complex 21st century skills such as problem solving and collaboration. This is very positive for Learnovate and its industry partners.

An obvious next step for Learnovate would be to partner with one of its industry partners to evaluate iLearn in a corporate setting with a different cohort of participants to establish whether the affordances identified in an education context can be reproduced in a workplace context using an authentic workplace task. If the results are reproducible, iLearn would have implications for how organisations recruit employees for specific skillsets, train and assess employees, manage their performance and development and identify competencies within their workforce. Furthermore, building on the iLearn task, the authentic workplace task could be extended to elicit behaviours associated with other complex 21st century skills such as decision making and critical thinking.

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10 The iLearn Trial captured in images

Figure 31: Real World meets Virtual World - team members line up in sequence with their avatars at the Eco Street scoreboard

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Figure 32: iLearn – Problem solving, fun and games, collaboration and total immersion

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