# PARTICIPATORY ROAD DESIGN

Dennis de Jong, CBC, CELTA, BsocSci, BSocSci Hons, MSocSci, PhD Canditate
University of Waikato
Gate 1 Knighton Road
Hamilton 3250
+64 7 856 2889
021 215 0656
dd9@students.waikato.ac.nz

## ABSTRACT

Traffic accidents kill approximately 1.2 million people worldwide annually. Currently efforts to reduce the road toll are limited mainly to enforcement, engineering and education and these have made significant impacts on accident rates, but many countries including New Zealand are now having difficulties in further reducing casualties. Despite possessing a wealth of knowledge regarding road conditions, driver behaviour and driver attitudes, drivers are largely overlooked as a resource for improving speed management and overall road safety. This paper investigates how participatory design can be used to use drivers' tacit knowledge to improve speed management as well as driver behaviour and attitudes. The current research has found that: participatory design, using drivers' knowledge has the potential to reduce speeds by improved road design; and that driver involvement in the process can positively affect driving behaviour.

### Keywords

Participatory design, driver behaviour, road safety, road design, driver attitudes

# INTRODUCTION

Automobiles and automobile accidents have gone hand in hand since the popularisation of the automobile in the 1900s (Flink, 1975). As a result, the trinity of the highway safety movement was developed by Julian Harvey in 1915. This trinity includes; enforcement, engineering and education, also known as the three Es. Despite an impressive decrease in the number of fatalities between 1970 and 2004 in many countries around the world (Organisation for Economic Co-operation and Development, 2006), the World Health Organisation estimates that there are still approximately 1.2 million people killed worldwide annually as a result of traffic accidents (World Health Organization and Association for Safe International Road Travel, 2007). There has also been a levelling off of progress in recent years. As a result, many countries are now unlikely to meet their fatality reduction targets set for 2010-2012 (Organisation for Economic Co-operation and Development, 2006). A survey of all 50 OECD member countries found that the top three contributors to accidents are; speeding; drink driving, and failure to wear seat belts. In New Zealand, figures show that 391 people were killed and 3219 people were hospitalised in 2006 with a social cost of NZ(2006)$3.045 billion. During this period, speeding was the number one contributor to serious and fatal crashes, with a total social cost of NZ(2006)$828 million. With speeding still causing so many accidents around the world it is clear that in terms of lives lost, injuries caused and economic cost, addressing the issue of speed management is still very important. In order to determine what can be done, it is important to first investigate the 3 Es, to determine how the current strategies are working to reduce speeds and improve road safety, what issues with the 3 Es may be contributing to the current levelling off of progress in reducing casualties, and how their efficacy could be improved. Moreover, considering the levelling off of progress in the past few years, it appears there is still room for exploring different strategies that may be used to reduce help reduce the incidence of speeding and the associated social and financial costs.

## Enforcement

Enforcement has been used for many decades to improve road safety. It has advanced over the years to include patrols, fixed and mobile speed cameras, hidden cameras, and laser speed guns (Stuster and Coffman, 1998). Enforcement has been very successful in reducing both speeds and accidents. Despite its successes, enforcement suffers from two major drawbacks. The first is that it is only effective at reducing speeds when there is consistent visible enforcement activity on the stretch of road where speed reduction is required. This limits its effectiveness over both distance and time. These are known as the distance and time halo effects. The effectiveness of enforcement outside its visible range can be anywhere from around 500 meters to several kilometres. In terms of time, once enforcement is removed, speed reduction effects can last anywhere from a few hours to around two months depending on the level of enforcement (Vaa, 1997). But regardless of the distance or time involved, enforcement does not have a lasting effect on speeds. Once the risk of apprehension is removed, drivers will eventually revert to their previous behaviour. This may be attributed to the fact that enforcement does very little to affect drivers' attitudes towards speed, apart from changing their attitudes towards apprehension (de Waard and Rooijers, 1994).

## Engineering

Road engineering works to ensure that roads are efficient, well maintained and safe (Transit New Zealand, 2007). However, the emphasis on efficiency and safety can lead to roads that have safety margins built in that are too large, leading to operating speeds in excess of the posted speed limit. An example below is River Road in Hamilton. This road is extremely wide and straight, yet has a 50km/h speed limit. As a result this road has issues with excessive speed and associated accidents, particularly with vehicles coming on to River road from adjoining roads.

*Figure 1*: River Road

Various measures are often put in place to improve road safety and reduce speed and accidents. These measures include traffic calming, signage (Charlton, 2006), and various methods of delineation. Despite being effective in many cases, these measures also have their drawbacks. Traffic calming can suffer from issues with public acceptance (Taylor and Tight, 1997) and this can lead to dissatisfaction and sometimes to their removal. Furthermore, due to their restrictive nature, traffic calming schemes are not practical in all locations (Institute of Transport Engineers, 1999). Signs must be used with care as they do little to affect speeds or driver behaviour by themselves. In addition, signs are often not recalled or noticed by drivers (Mōri and Abdel-Halim, 1981). The use of delineation to reduce speeds must also be done with care as some forms of delineation may be subject to habituation thereby losing their effectiveness.

If used correctly, engineering measures are capable of generating reductions in operating speeds and reducing accidents. However, as with enforcement, engineering solutions also have drawbacks and drivers and the public often have very little involvement in their implementation aside from being informed of impending changes. Some of the drawbacks suffered by speed reduction methods may be addressed by increasing the involvement of drivers and the public in their design. Literature from traffic calming demonstrates that public involvement can improve the efficacy and perception of traffic calming schemes and the same may be the case for other engineering solutions. Increased driver and public involvement may also help to ensure that roading authorities can quickly and efficiently respond to situations were intervention is required to improve road safety.

### Education

Driver education and training aims to improve driver behaviour by informing drivers and improving their skills. However, several inconsistencies exist in the literature, with large-scale studies showing very little effect on accident rates for both driver training and education. Some authors feel that including the teaching of reflective skills may help to improve the efficacy of driver education programs. The ANDREA project, which set out to determine whether rehabilitative education programs were successful in reducing recidivism, found that several programs for reintegrating drunk drivers were able to reduce recidivism rates of participants by around 50%. The successful programs used small groups and focused on the individuals in the groups reflecting on themselves and their behaviour. Based on mixed results regarding the efficacy of education and training reported in the literature it is clear that there is also room for improvement in this area of road safety improvement.

### Self Explaining Roads

Self explaining roads or SER, are based on the cognitive principle that people attempt to structure their worlds and use these structures in order to develop a set of internal rules or scripts which are then used to ensure the correct behaviour for any given situation. SER uses three guiding principles, which are, functionality, homogeneity, and recognisability (Theeuwes and Godthelp, 1995). These are then used to develop categories of road. Although the principles are sound and an initial study in the Netherlands has shown promising results, literature on the ability of SER to improve road safety remains scarce.

## SUMMARY AND RESEARCH QUESTION

Based on the above literature and road casualty statistics it is clear that improvements to the three Es are necessary to further facilitate the ability of roading authorities to manage speeds and further reduce accidents. Despite the fact that drivers and the general public are likely to have a wealth of tacit knowledge about roads, traffic conditions, their own behaviour and attitudes, they appear to be treated as a problem that needs to be enforced, engineered or educated into shape. At best they are treated as a source of information about problematic behaviours, but are not heavily involved in attempting to facilitate improvements in speed management techniques, road safety or driver behaviour. One method of involving drivers and the public in the improvement of road safety is participatory design. The research questions are thus whether employing participatory design to utilize the tacit knowledge held by drivers and the public can be used to a) improve road design and b) help to improve driver behaviour and attitudes.

## PARTICIPATORY DESIGN

Participatory design may offer a way to increase the meaningful involvement of drivers in the implementation of speed management strategies and offer a way to improve driver behaviour and attitudes. Participatory design focuses on eliciting people's tacit knowledge and involving users/workers in every stage of a design process as equal partners (Spinuzzi, 2005; Ehn, 1993).

Three basic stages can be seen in almost all participatory design research (Spinuzzi, 2005). The first stage involves designers meeting with users to familiarize themselves with how the users work with each other. Workflow, work procedures, routines, teamwork and other aspects of the work are also investigated. In the second stage, designers and users work together to envision the new workplace and look at work organisation structures. User's goals and values are also defined in order to determine the outcomes of the project. The third stage is where the ideas that were envisioned in stage two are further developed. Users and designers work together to iteratively shape prototypes. Usually these stages are iterated several times to improve the design process by allowing better exploration of issues by the same users and designers.

Participatory design may also allow participants to become more aware of their own ideas and attitudes so that they may be able to change them, especially since involvement in issues can lead to more critical assessment of one's decision making processes (Maheswaran and Meyers-Levy, 1990). An example of this may be using a participatory design process with older people to develop a mock up of a mobile phone. Not only would they benefit from learning how something like this may be produced, but they also have the opportunity to learn about or become more aware of new technology and perhaps change their attitudes towards it. The present study aimed to investigate whether participatory design can improve an existing road design, influence drivers' attitudes and/or behaviour, and change perceptions of roads.

# METHODS

A participatory design workshop was held with 28 participants to determine whether it could be used in order to redesign River Road (Figure 1) with the aim of reducing speeds and improving road safety. Those who took part were also surveyed regarding their attitudes towards speed, their driving behaviour and perceptions of roads. Figure 2 below shows the design workshop in action.

*Figure 2:* Workshop in progress

## Participants

Twenty eight participants, 10 females 18 males took part in the experiment. Their ages ranged from 15 to 76 (mean 40.18, SD 18.56), they drove between 0 and 120,000 kilometres per year (mean 27,569.57, SD 35,290.26), had between 0 and 60 years of driving experience (mean 23.48, SD 18.94), a mean of 0.04 infringements and no crashes.

## Procedure

To determine the effectiveness of the workshop in improving road design, drivers' attitudes and driver behaviour, all participants who took part in the workshop, including the redesign teams, the audience members and the participating engineers, were given three questionnaires. The first was given prior to the workshop and asked participants to (using self completion questionnaires)

- Rate several roads (the road to be redesigned in the experiment and 8 control roads [selected on the basis that some had design issues that made selecting the appropriate driving speed difficult for drivers]) in terms of
    - Estimated speed (participants were asked how fast they would drive on this road if they were to use it and record this speed in kilometers per hour.)
    - Safety (on a scale of 1-5, 1 with 1 being very unsafe and 5 being very safe)
    - Aesthetics (with 1 being poor and 5 being excellent)
    - Preference (how likely they were to use the road, 1 very unlikely – 5 very likely)
    - Liveability (with 1 being poor and 5 being excellent)
- Their driver behaviour in the year previous to the workshop (using the Driver Behaviour Questionnaire (DBQ). This questionnaire asks how often drivers commit various aggressive violations, violations, errors, and lapses )
- Attitudes towards speed
    - The attitude section was split into three parts, the first section concerned attitudes towards enforcement and speed, the second section asked participants how they felt about punishments for driving over the speed limit, and the third section dealt with general attitudes towards speed and enforcement.
    - This section asked questions regarding; age, driving experience, kilometers driven annually, and accident and infringement history

The second questionnaire was given after the design portion of the workshop and asked participants to

- Rate (using the same measures used for the control roads) the road that had been redesigned during the workshop
- Their attitudes towards speed (using the same measures as in the first questionnaire)
- The design workshop
    - Participants rated the workshop as a road design and teaching tool, as well how much they felt they and others around them were able to contribute to the workshop

The follow up questionnaire asked participants to

- Rate the control roads (using the same measures used previously)
- Their driver behaviour (using the DBQ) one month following the workshop
- About their attitudes towards speed

The participatory design workshop began with a 15 minute presentation that outlined road accident statistics, methods used for reducing speeds and accidents, and details regarding the road that was to be redesigned. Ten participants and two road engineers made up 2 teams of 6 and the remainder made up the audience. Participants in the teams were then instructed to begin their design process, which took approximately one hour. No constraints were placed on how they were allowed to redesign the road. Approximately half way through the process, the audience was asked to take part in the design process more directly by asking questions and providing comments and inputs for approximately five minutes.

Once the designs were completed, a representative from each of the teams gave an oral description and rationale of their designs. The audience was also allowed to ask questions regarding the designs that the teams had come up with. After this was completed, the participants were asked to fill in the second half of the questionnaire and rate the roads designed by each of the teams. During this time the researcher took photographs of the designs that the participants came up with. Questionnaires were also collected at this time. Approximately one month after the workshop, the follow up questionnaire was sent out and collected and analysed.

## RESULTS

Participants came up with the following road designs:

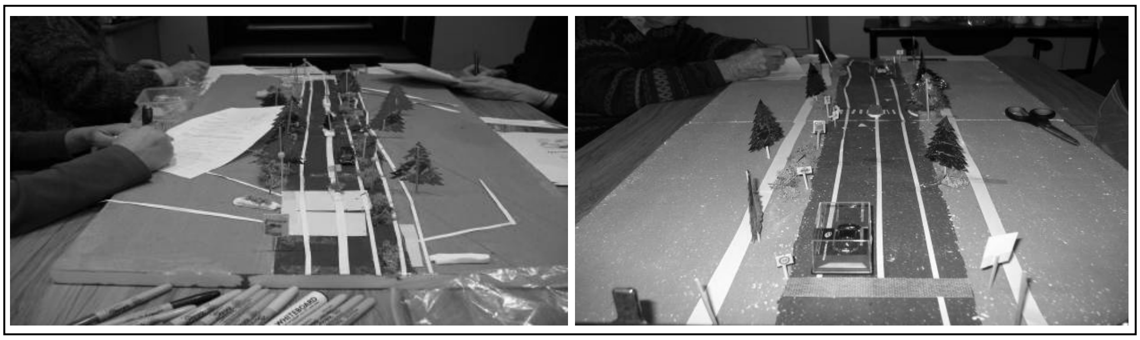

*Figure 3*: Road designs team 2 (left) and team 1 (right)

In order to determine whether any differences in road ratings existed before and after the workshop and between teams, a 2 X 2 mixed design Multiple Analysis Of Variance (MANOVA) using the variables of road safety, aesthetics, preference, liveability and speed was done. The MANOVA was significant, Wilks' Lambda = .287, $F(10,12) = 2.98$, $p < .05$, and univariate tests revealed that both road safety ratings and estimated speed ratings were significantly different. $F(2, 42) = 3.3$, $p < .05$ and $F(1.32, 27.71) = 14.48$, $p < .001$. Estimated speed was found to be significantly different after the workshop, both teams managed to reduce estimated speed ratings with team one reducing speed from an estimated 66.4km/h (SD = 15.17) to 54.4km/h (SD = 8.70) and team two to 52.22km/h (SD = 9.34),The decrease in estimated speed can be seen in Figure 4 below.

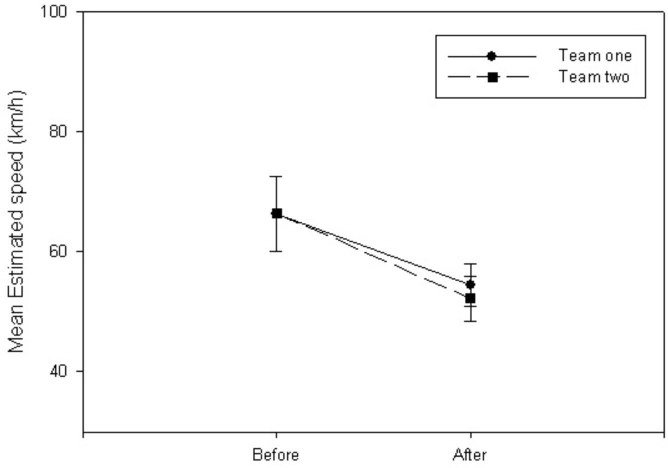


*Figure 4:* Estimated speed rating changes for team one and team two (95% CI)

Post hoc tests revealed that safety ratings for the road between teams was different, with team one (mean = 3.28, SD = 0.82) having lower ratings than team two (mean = 3.83, SD = 0.63), $p < .05$.

Other ratings were not significantly different, although the graph below does show that both teams managed to improve liveability ratings. Team one's ratings for aesthetics and preference were lower, though not significantly, than both team two's ratings as well as the before ratings.

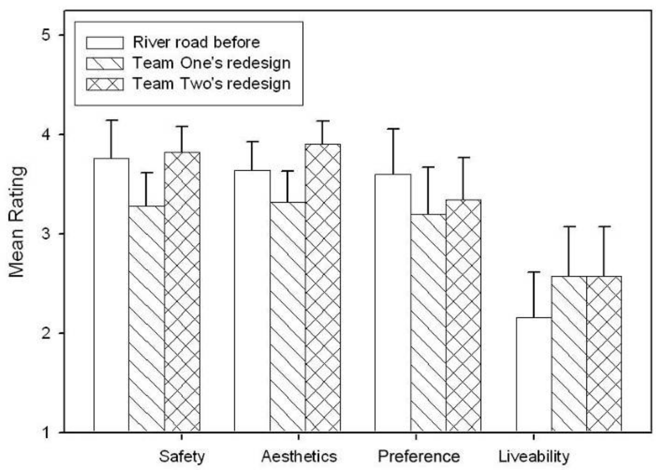


*Figure 5:* Mean road safety, aesthetics, preference, and liveability ratings for river road before the workshop and for teams one and two after the workshop (95% CI)

## Control road ratings

Participants also rated the safety aesthetics, preference, liveability and speed of eight control roads before and one month after the workshop. Each of the roads rated by participants was analysed separately using a repeated measures MANOVA with five dependent variables (road safety, aesthetics, preference, liveability and speed). Out of the eight roads, two were significantly different in their ratings, road two and road three (Wilks' Lambda = .36, $F(5, 12) = 4.22$, $p < .05$, Wilks' Lambda = .40, $F(5, 12) = 3.58$, $p < .05$). Road two had a significant drop in speed ratings from an average of 62.35km/h (SD = 11.34km/h) to 56.94km/h (SD = 9.73) and road three had a drop significant drop in mean aesthetics and liveability ratings, 3 (SD = .87) to 2.53 (SD = .87) and 2.51 (SD = 1.33) to 2.18 (SD = 1.19) respectively. The graph below shows that ratings for roads with an already low estimated speed rating remained stable.

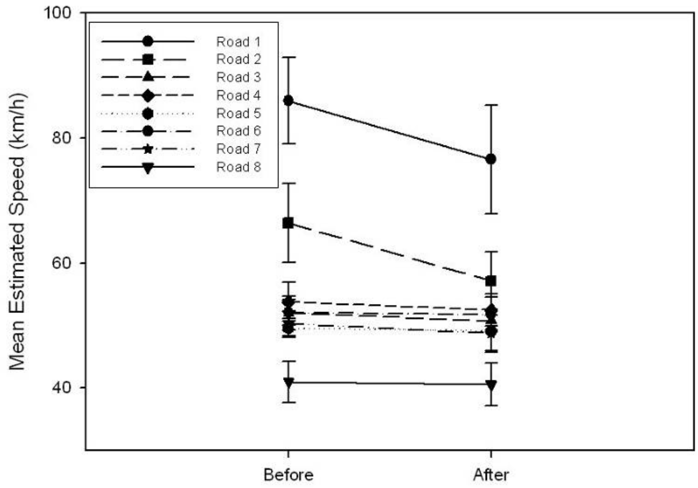


*Figure 6:* Estimated speed ratings before and one month after the workshop

## Attitudes towards speed ratings

Repeated measures MANOVAs were done on each of the three sections of the attitude questionnaire to find out whether any differences existed in attitude before and after the workshop. No significant differences in attitude were found.

Participants were also asked directly whether they felt the workshop had changed their attitudes and whether they felt that everyone was able to take part in the workshop. Eleven out of 28 (39.3%) felt that their attitude towards driving had changed as a result of the workshop. A Mann-Whitney test revealed that differences in attitude ratings existed between team members and audience members. One person reported an attitude change and 10 reported no change for team members, whereas 10 audience members reported an attitude change and 6 did not, $U = 44$, $p < .01$.

## One month follow up survey for attitude towards speed ratings

The measures and analyses used were the same as in the before and after study mentioned above. The first two sections did not yield any significant results, however, the third section had a significant MANOVA result, Wilks' Lambda = 0.22, $F(7, 9) = 4.61$, $p < .05$. A univariate analysis revealed that participants were less likely to report that they knew exactly how fast they could drive and still drive safely, $F(1, 15) = 13.97$, $p < .01$. Prior to the workshop the average score for this question was 4.00 (SD = .82) and after the workshop the average score was 2.87 (SD = 1.31).

### Workshop ratings

Participants were also asked to rate the workshop as a way to improve road design and as a teaching tool. The workshop was rated a mean of 3.80 out of 5 (SD = 1) as a design tool and 4.04 out of 5 (SD = 1) as a teaching tool. A total of 24 out of 28 (85.7%) participants said they felt that everyone was able to participate in the workshop.

### Changes in driver behaviour

Driver behaviour was rated before and one month after the workshop. A repeated measures MANOVA with four dependent variables (violations, aggressive violations, lapse and errors) was done to determine whether any changes in participants' self reported driving behaviour took place in the month following the workshop. The MANOVA revealed significant changes in self reported driving behaviour. Wilks' Lambda = .22, $F(4, 14) = 12.34$, $p < .05$. Univariate analyses found that self reported violations and lapses both fell significantly, with violations falling from an average score of 6.11 (SD = 4.89) to 4.56 (SD = 5.09) and lapses from a mean of 8.56 (SD = 3.69) to 4.78 (SD = 3.69). $F(1, 17) = 4.50$, $p < .05$ and $F(1, 17) = 14.60$, $p < .01$. The graph below shows a tendency for reports of aggressive violations and errors to fall in the month following the workshop.

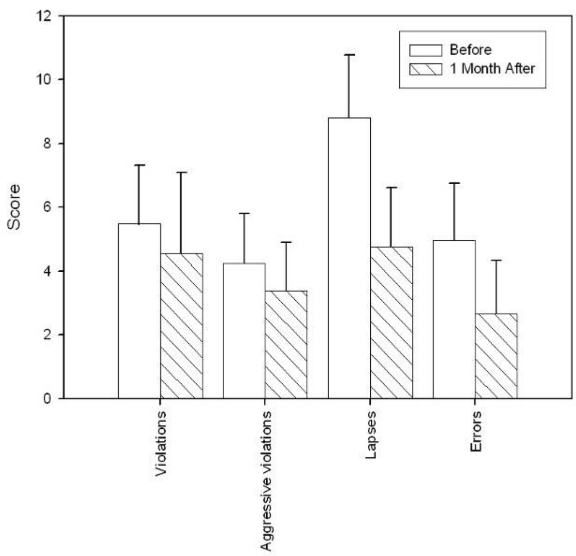


*Figure 7:* DBQ measures before and one month after the workshop

## DISCUSSION

Through the participatory design workshop both teams to reduce estimated speeds for River Road from an estimated 66.4km/h to approximately 50km/h (Figure 4), a substantial reduction of more than 10km/h, bringing estimated speed ratings very close to the actual speed limit for the road. As speeds were measured using self ratings, it is not possible to say the estimated speed ratings given by participants after the workshop would equate to the same speed reductions in a real world setting. However, the estimated speed ratings given by participants for this road prior to redesign was in line with the average speed recorded on this road, which was approximately

65km/h. This indicated that participants were accurate in their ratings of speed for the road prior to redesign. Additionally, estimated speed ratings given after the workshop were still above the posted speed limit for the road (Figure 4), indicating that participants were not simply using 50km/h as a set rating, but rather rating the road on its design. Furthermore, although, they were unable to significantly improve other ratings for the road in question, these ratings were already relatively high and not adversely affected. Given that traffic calming can have issues with public acceptance, this is a positive finding. The relatively short length of time of the workshop, approximately 1.5 hours, also showed that participatory design can facilitate the generation effective solutions using drivers' tacit knowledge in a short time without opposing views and conflict causing additional issues. However, it must be said that the final solutions arrived in the experiment would probably require additional meetings to allow more iterations to ensure that solutions met other criteria, such as fitting within budgets and ensuring that the maintenance of the road was manageable. Additionally, participants also rated the workshop very highly indicating that they not only felt involved, but were also happy to be involved, making this type of workshop an ideal substitute for or addition to current consultation processes.

The process positively affected participants' behaviour, with self-reported violations and lapses falling significantly and participants also reported fewer aggressive violations and errors in the month following the workshop (Figure 7). Although there were no actual speed data available for the control roads, all had a 50km/h posted speed. They were selected on the basis that some had issues, in that their design (due to design features, such as road width, types of delineation and other variables) made them appear to have higher speed limits than they actually did. They were ranked in this order, from road 1 looking the fastest to road 8 looking the slowest. Ratings demonstrated that speed ratings were in line with the rankings, but as evidenced by the fall in estimated speed ratings for the control roads (Figure 6), participants decreased their estimated speed ratings for the fastest looking roads. This may be due participants being more aware of cues in the road environment that they had previously missed, such as the surrounding environment or delineation treatments. It may also have indicated a more cautious approach in the way that participants selected their speeds overall. This more cautious approach may have been due to the experience of redesigning a poorly designed road. Therefore, when they saw other roads where judging speeds simply by design and environment was difficult, participants may simply have adjusted their estimated speed judgements downwards. The finding that participants no longer felt as confident that they knew how fast they could drive and still drive safely also indicates a more cautious approach to driving.

The above findings have implications for both enforcement and education. Enforcement does not work unless it is consistently present as it does not affect drivers' attitudes (de Waard and Rooijers, 1994) and by the same token, it also does nothing to affect behaviour in the long term. The improvements in behaviour and possible improvements in road environment awareness reported by drivers' indicate that they were able to manage their own behaviour better. This could lead to a decreased reliance on enforcement in the future.

Given that the literature on education is somewhat mixed (Dorn and Barker, 2005) , there is clearly room for improvement in driver education. Despite the fact that the main focus of the participatory design workshop was to redesign a road, the reported positive changes in self-reported behaviour and improvements in speed choice, demonstrate that participatory design has potential as an educational tool. However, this would require further investigation perhaps using participatory design workshops with an increased focus on the educational elements of road design and road safety.

As a participatory design process, the experiment was successful on the whole, with both teams achieving their main goal of reducing estimated speed ratings on the redesigned road and almost all those involved giving the process high ratings. However, team one's road ratings were lower overall than team two's ratings (Figure 5). This may be explained by the fact that members in team one commented that there were some members in the team who tended to be somewhat unbending in their views. This type of disruptive influence has been reported in previous participatory design literature as decreasing the ability of participatory design processes to generate successful solutions. More facilitator intervention may have resolved these issues.

Unfortunately, attitudes remained largely unchanged as a result of the workshop. It is not clear as to why attitudes remained unchanged given that improvements in behaviour were found. The difference in reported attitude changes between teams and audience members is also somewhat perplexing. It is possible that a more qualitative approach to measuring attitudes may be required in future studies in order to determine what internal processes participants went through as a result of the workshop.

Finally, this study was subject to some limitations. As the workshop was run with a relatively small number of people, the small sample size means that results must be interpreted with some caution. Furthermore, findings were based on participants' self-reports, meaning that they are not as reliable as having behavioural evidence. However, gathering behavioural evidence for participants over one month was outside the scope of this study and the DBQ has been found to be a reliable measure of behaviour. Finally due to time constraints, the roads developed were only prototypes and required further development in order to be useable in an actual setting.

## FUTURE DIRECTIONS

In order to further explore the efficacy of participatory design as a design and teaching tool in the context of road safety and design, there are further issues that should be explored. First, a longer term participatory design process with realistic budget, time and other constraints should be undertaken to further determine the efficacy of the process in redesigning roads. This should also include a pilot road to establish whether the designs would be successful in an actual setting. It is important to determine why attitudes were not changed by the workshop and how the workshop process could be improved to better influence attitudes. This may require a more qualitative approach to determine participants' internal processes. A participatory design workshop focused more on education may also be of some benefit.

## CONCLUSION

Participatory design was successful in improving driver behaviour. Therefore those who exhibit dangerous driving behaviours may be positively influenced by being involved in a participatory design process as part of a driver education program. However, attitudes did not appear to be affected. In this experiment, participants redesigned a road and reduced their estimated speed ratings for the redesigned road, these decreases in estimated speed ratings were consistent for both those who actively redesigned the roads, as well as those who took part as an audience. Given these positive findings, it appears that using participatory design to help improve the effectiveness of the three Es is worthy of further study.

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