A Knowledge Gap Assessment Tool for Interface Design and Research

Technical Report HFA-TR-1007

Atlanta, GA: Georgia Institute of Technology

School of Psychology – Human Factors and Aging Laboratory

2010

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1. Executive Summary

The general goal of this project is to study user knowledge in the context of purportedly "intuitive" user interfaces. Ideally, we want to develop assessment tools and protocols to evaluate how knowledge is incorporated into these interfaces. This is the third report in a series. We first conducted an in-depth literature review to identify the definitions and design attributes relevant to the general construct of intuitive design (O'Brien, Rogers, & Fisk, 2010). We then developed an organizing framework called the Knowledge Taxonomy to systematically assess and document human-machine interface knowledge in activities related to the design and evaluation of user interfaces, in particular, interface knowledge required for successful interactions with a specific design (Serrano Bacquero & Rogers, 2010).

The Knowledge Taxonomy encompassed a hierarchy of six high-level categories (and their sub-categories) that capture knowledge required by a user to successfully interact with a prototype design. This knowledge pertains specifically to displays, controls, procedures, context of operation, additional equipment involved, and other interfaces that share commonalities with the given design. In the present report we provide an overview of a Knowledge Gap Assessment Tool, illustrated with the example of a John Deere X749 Ultimate Tractor.

In the first step of this application, the Knowledge Taxonomy is used to assess, in a comprehensive fashion, the knowledge demands that a prototype design imposes for a majority of users. This is accomplished by first determining a set of benchmark tasks, the main tasks to be performed with the interface, with users, and members of the design team. Next, all instances of required knowledge pertaining to displays, controls and procedures (for each benchmark task) are to be compiled using the Knowledge Taxonomy as a template. The corresponding sub-categories in the Knowledge Taxonomy were used to identify and organize this knowledge from instructional material, simulations, or direct contact with the prototype design.

The Knowledge Taxonomy is then used in an assessment of interface knowledge that users currently have about a prototype design as well as knowledge activated in these users when presented with such design. This can be accomplished by labeling and defining an Interface Family of related interfaces that the prototype design belongs to, with users and designers. This label and definition can be used to create a survey instrument for users where specific Knowledge Taxonomy categories (as described in the report) are expanded into questions and probes that will elicit knowledge respondents have about the prototype design, related interfaces, and their experience with both.

The outcomes from the two previous assessments can then be compared quantitatively or qualitatively with the level of granularity desired, to identify topic areas where users lack required interface knowledge, where they meet interface knowledge requirements, or where available knowledge conflicts with that required. In this way, the proposed guide supports a highly-targeted approach to the assessment of training needs and the design of training curricula and materials. A summary of the steps involved to implement the proposed Knowledge Gap Assessment Tool is provided in Table 1.

Table 1. Implementation Summary for the Knowledge Gap Assessment Tool.

	Necessary steps
1	Determine benchmark tasks as the main tasks that users will be performing (with users).
2	Determine benchmark tasks as the main tasks that users will be performing (with design team).
3	Contrast benchmark tasks defined in steps 1 and 2 and unify into a single set.
4	Compile required interface knowledge for prototype design and benchmark tasks.
5	Label the Interface Family that the prototype-design belongs to (with users).
6	Label the Interface Family that the prototype-design belongs to (with design team).
7	Contrast Interface Family labels created in steps 5 and 6 and unify into a single label.
8	Create a glossary definition for the Interface Family to use in current user knowledge assessment.
9	Create a two-part survey instrument that elicits respondent interface knowledge and experience based on Knowledge Taxonomy categories. Provide examples from required interface knowledge.
10	Complete surveys with users from relevant user profiles.
11	Compare required knowledge with current user knowledge to identify knowledge gaps.

2. Introduction

We approached the study of attributes that characterize intuitive technology interactions, with the goals of developing assessment tools and protocols to evaluate these attributes in interfaces, to understand how prior experience with distinct products and contexts could be leveraged in these interactions, and to develop tools that could support designers in incorporating these attributes into their interfaces. In the first stage of this process, we conducted a systematic review of the literature related to intuitive design (O'Brien et al., 2010). Based on the analysis of the literature we developed a framework for intuitive human-computer interaction (HCI).

In the next stage, documented in a previous technical report (Serrano-Baquero et al., 2010), we used this framework for intuitive HCI and incorporated other models of HCI to illustrate the importance of user interface knowledge (and operations that users perform with knowledge) for successful interactions with novel technologies. Interface knowledge is a component of HCI in primarily two forms. Knowledge that users accumulate through experience, culture, and their abilities (i.e., *knowledge in the head*); and knowledge that is available to users in the moment of the interaction, through affordances, instructions, and labels (i.e., *knowledge in the world*). The availability of the latter in a prototype design and its support to elicit and guide use of user-accumulated knowledge, can be a determining factor in the success or failure of an intuitive interaction.

We developed a Knowledge Taxonomy that could be used to organize human-machine interface knowledge required for successful interactions. We developed this framework to be complete, in that it would capture all the different facets of interface knowledge in context; flexible, in that it would be used in activities where varying information is available about the interface, the context and the environment of operation; and we developed it to be scalable, in that it should be applicable to document knowledge about different interface types, interaction styles, modalities and product lines.

The Knowledge Taxonomy can be used to systematically assess, document and communicate user interface knowledge in activities that design and research teams engage in as part of user interface

design and evaluation. These applications are proposed in the aforementioned technical report in the form of five potential applications for the Knowledge Taxonomy.

As a continuation of our work in further developing potential applications for this Knowledge Taxonomy, this technical report describes a proposed guide to 1) assess and document the knowledge demands imposed by a prototype design, 2) assess and document interface knowledge that users currently have about a prototype design, and 3) combine the outcomes of the two previous assessments into a knowledge gap assessment that highlights weaknesses to address with training programs and materials.

In this report, we provide a brief overview of the components that make up the Knowledge Taxonomy (for more details see Serrano Baquero et al., 2010). We then introduce an exemplar interface from a Deere & Company product that is used to illustrate the guide. This is followed by the description of the steps that make up the Knowledge Gap Assessment Tool implementation, the primary outcomes of each step, as well as additional outcomes that can serve other analyses.

3. Overview of the Knowledge Taxonomy

In the development of the Knowledge Taxonomy, interface knowledge required to interact successfully with five commercial interface implementations was considered. These interfaces were selected to be representative of different interface implementations, contexts, and platforms. We selected a word-processing application (Microsoft Word 2007), an institutional web portal (Medicare.gov), an automated Interactive Voice Response system (Amtrak 1800-USA-RAIL), the John Deere 6615 utility tractor in an orchard mowing application, and the John Deere Greenstar 2 Management Console.

We started development of the Knowledge Taxonomy with the compilation of an inventory of knowledge required to complete specific benchmark tasks with the interfaces mentioned above. Next, similar to developing a coding scheme, two researchers followed numerous iterations to synthesize a mutually-exclusive categorization for interface knowledge and definitions. The resulting Knowledge Taxonomy is comprised of six-high level categories that capture different aspects of required interface knowledge (Figure 1).

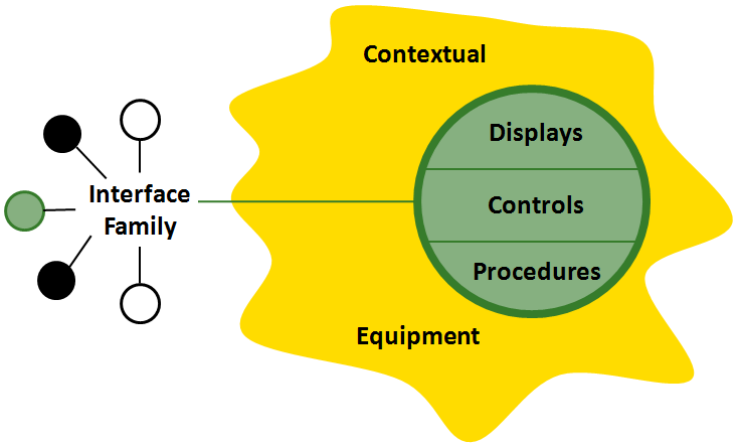


Figure 1. The Knowledge Taxonomy and its six categories of knowledge.

The first of the six high-level categories, Interface Family Knowledge, can be used to document general knowledge common to a collection of interfaces, that can be given a group label, and that share additional similarities:

- **Interface Family Knowledge***: Knowledge that a user requires that is common to a collection of interfaces and not specific to a system or task.*

The next five high-level categories can be used to capture interface knowledge required to interact with a specific interface implementation, like a prototype design being considered. The three categories described next can be used to capture knowledge required about the design of the interface and its operation:

- **Specific Displays Knowledge***: Knowledge a user requires about means with which to perceive the state of a specific interface.*
- **Specific Controls Knowledge***: Knowledge a user requires about means with which to provide input to a specific interface.*
- **Specific Procedures Knowledge***: Knowledge about how to use a specific interface to complete a task.*

When available, the framework can be used to organize knowledge about factors that are external to the interface but are critical to successful operation. The Knowledge Taxonomy captures this knowledge in the last two of the high-level categories:

- **Contextual Knowledge***: Knowledge a user requires about factors external to the interface and that affect task performance.*
- **Equipment Knowledge***: Knowledge a user requires about specific mechanical components that support system use.*

Error! Reference source not found. 2 presents a summary of the high level categories in the Knowledge Taxonomy, as well as detailed definitions of the sub-categories that each one encompasses. The sub-categories can be used to document user interface knowledge with greater granularity. .

Table 2. Categories and Sub-Categories of the Knowledge Taxonomy

	Sub-categories	Definitions
Interface Family Knowledge: Knowledge a user requires that is common to a collection of interfaces and not specific to a system or task.	Family name	The label that identifies the Interface Family that a prototype design belongs to
	User goals	Common objectives that can be achieved with all interfaces in an Interface Family
	Available tasks	Activities that can be performed with all interfaces in the family
	Task flow	The sequence of use common to the family
	Common displays	Display attributes (e.g., information content, placement, modality) that extend across the family
	Common controls	Control attributes (e.g., type, location, operation, coding) that extend across the family
Specific Displays Knowledge: Knowledge a user requires about means with which to perceive the state of a specific interface.	Color	Meaning of color, saturation, and hue combinations used
	Icons	Representations of objects, actions or scenes used (excludes alphanumerical characters)
	Layout	Arrangement of display components
	Saliency variations	Meaning of differences in how display components are exposed
	Sensory modality	Type of stimulus used by the display (auditory, visual, somatosensory, olfactory, gustatory)
	Textual labels	System of words and alphanumerical characters from a specific set used to identify display components
	Related event	System occurrences notified to the user through a change in the display
Specific Controls Knowledge: Knowledge a user requires about means with which to provide input to a specific interface.	Appearance	Cues that inform users that an interface element is a control and its affordances
	Feedback	Interface response that follows user input through a control
	Function	What the control does
	Layout	Arrangement of control components
	Operation	Method with which a control can be manipulated
	Sensory modality	Type of stimulus required for input (auditory, visual, somatosensory)
Specific Procedures Knowledge: Knowledge about how to use a specific interface to complete a task.	Available tasks	Activities that can be performed exclusively with a specific interface
	Task flow	The sequence of use specific to a task and a prototype design (functions)
	Interface modes	Different system states that render different responses to a given input
Contextual Knowledge: Knowledge a user requires about factors external to the interface and that affect task performance.	Environment	Knowledge a user has about his/her physical surroundings
	Lexicon	Terminology inherent to the task
	Organizational	Rules or guidelines that must be considered in task (when interface is associated with organization)
	Social nature	Knowledge about the individual or collaborative nature of supported tasks
Equipment Knowledge: Knowledge a user requires about specific mechanical components that support system use.	Installed equipment	Attributes of existing system mechanical components used in the task
	Optional equipment	Attributes of available components that are not part of the system but that may be used in the task
	Maintenance	Procedures required to keep components in good working order
	Problems	Technical difficulties that components can experience

4. Conducting a Knowledge Gap Assessment

Serrano Baquero et al. (2010) described potential applications for the Knowledge Taxonomy. These potential applications included the assessment of knowledge demands imposed by a prototype design, where the Knowledge Taxonomy (**Error! Reference source not found.** 2) is used as a template to organize and document knowledge required to interact successfully with a prototype design. This can facilitate the communication and documentation of knowledge in design and evaluation activities.

The Knowledge Taxonomy can also be used in an assessment of user interface knowledge that users bring to the interaction with technology. Such a procedure can be conducted in different stages of research and design activities (e.g., before, during, and after training), and relies on user self-report of knowledge in the head. In this section we propose a guide to analyze the outcomes of the two aforementioned assessments and identify knowledge gaps and weaknesses that can be addressed with training programs and materials. This guide, called the Knowledge Gap Assessment Tool, constitutes a targeted approach to determining training needs.

To illustrate the description of the steps involved in this guide, we used a Deere & Company product, the John Deere X749 Ultimate Tractor (Figure 2) as an example in the use of the Knowledge Gap Assessment Tool. In the appendix, we include samples and materials based on this product for all the deliverables mentioned below, in each step of the guide.

Figure 2. The John Deere X749 Ultimate Tractor used as example.

4.1 Assessment of knowledge demands by prototype design

The proposed process (Figure 3) starts by determining a set of benchmark tasks, the main tasks that will be performed with the prototype design. These tasks will be used to provide a context to the assembly of the knowledge inventory. These tasks are first determined with users of the prototype design and then determined with representatives of the design team (these can include all product stakeholders: marketing, product management, engineering, and interface designers). Contrasting the mismatches between tasks and their priority as identified by each group is an opportunity for richer analysis in which conflicting perceptions might be found between these product stakeholders.

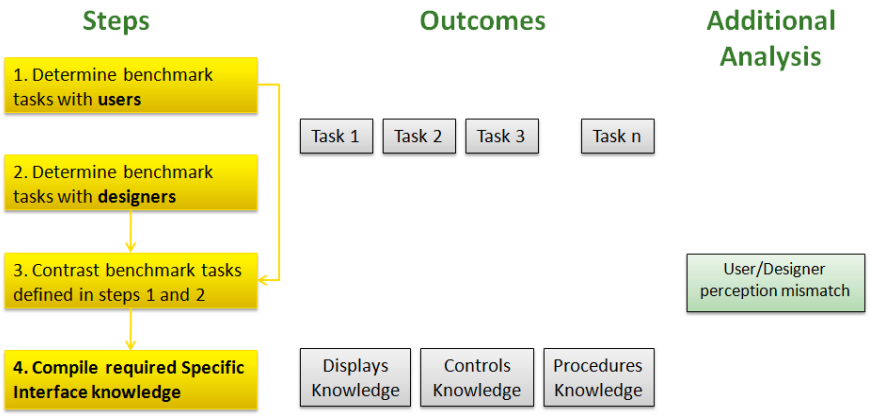


Figure 3. Using the Knowledge Taxonomy to assess knowledge demands by a prototype design.

With a unified set of benchmark tasks, the required specific interface knowledge is compiled using the Knowledge Taxonomy as a template (Specific Displays, Controls, and Procedures categories and sub-categories). This is accomplished by listing required interface knowledge for each benchmark task, using the sub-category definitions (**Error! Reference source not found.** 2) as probes, while performing a documentary review of available materials (operation manuals, simulators) and/or direct interface interaction (Figure 1). A sample of materials used in the example discussed below (John Deere X749 Ultimate Tractor) is provided in Appendix A and the Knowledge Inventory of required interface knowledge compiled for the same example is provided in Appendix B.

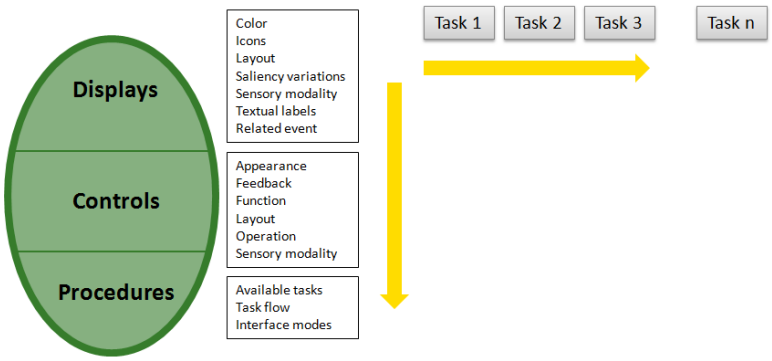


Figure 4. Compiling an inventory of required interface knowledge.

4.2 Assessment of current user knowledge

This process (Figure 5) begins with the definition of a label for the Interface Family that contains the prototype design. Similar to the assessment described in the previous section, the label should be determined with users as well as with members of the design team. Further study can be conducted by comparing the labels produced by these two groups. This can identify differences in knowledge activated by the user when interacting with a prototype and knowledge that designers intended to activate.

With a unified Interface Family label, a glossary definition for the label needs to be created, that will be incorporated in documentation and survey instruments. The label and definition will be used in a self report survey instrument to probe respondents and query them on their current interface knowledge. The label and definition should also reflect the project and/or research objectives, to include brands, product families, or competitor products that respondents should think about.

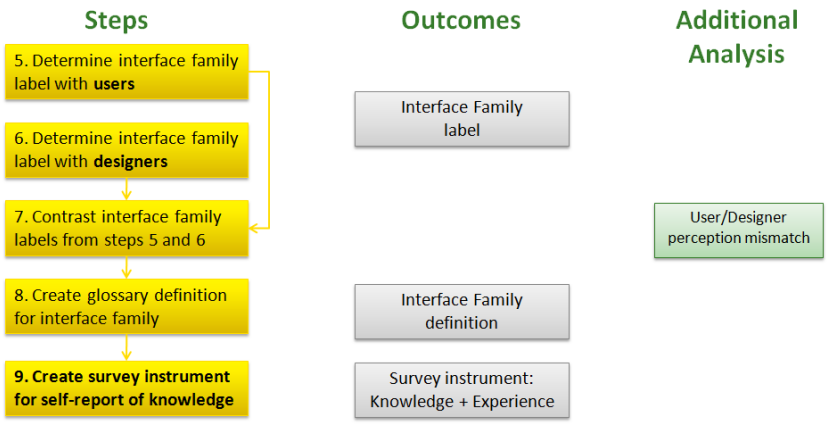


Figure 5. Assessment of current user interface knowledge.

Next, a two-part survey instrument for users to self-report on current interface knowledge is developed. Each survey part starts with the Interface Family label and definition in an introduction, and questions are developed by expanding on selected categories from the Knowledge Taxonomy, as discussed below (Interface Family, Contextual, and Equipment Knowledge). Examples and multiple choice answers should be populated with knowledge compiled in the Knowledge Inventory. Question formats and illustrations should be selected to require the least effort from the respondent to complete.

The first part of the survey is designed to help users verbalize interface knowledge available to them about the specific prototype design and about related interfaces. The second part of the instrument asks users about their experience with related interfaces (as defined in the Interface Family) to identify the source of available interface knowledge. A complete sample of the two-part survey is provided in Appendix C.

First, respondents are presented with the label and definition for the Interface Family, that is, the collection of interfaces they should consider in their answers. Next, the sub-categories in the Interface Family taxonomy category are expanded into questions that probe users as described below:

- *Family label*: Questions are created expanding on this category to determine the appropriateness of the Interface Family label and definition. Users are asked to describe in their own words graphics of the prototype design and its interface components.
- *User goals, Available Tasks, Task Flow*: These categories are expanded into questions populated with the Knowledge Inventory, to identify the most accessible knowledge users have about goals and the sequence of steps associated with performing tasks with the prototype design.

To assess knowledge that respondents might have about the specifics of the prototype design, questions are created based on some of the Specific Displays → *Related events, Color, Icons, Saliency variations, Sensory modality, Textual labels, Layout* subcategories; and Specific Controls → *Appearance, Layout, Feedback, Operation, Sensory modalities* subcategories.

Questions are also created based on the Contextual Knowledge → *Environment* sub-category, to identify the most accessible knowledge users have about the context of operation and its impact on operation; and the Equipment Knowledge → *Installed Equipment* sub-category to identify accessible knowledge about mechanical equipment that supports operation, its availability and applications.

In the second part of the survey, that assesses experience with interfaces, respondents are presented with questions that expand on some of the sub-categories in the Knowledge Taxonomy to trace the source of knowledge verbalized in part one, to a type of interface in the Interface Family, and how it was acquired. The sub-categories in the Interface Family category are expanded into questions as described below:

- *Family Label, User Goals, and Available Tasks*: Questions based on these sub-categories assess the experience respondents have with interfaces related to the prototype design. They are asked about the frequency of their experiences with distinct interfaces, as well as with performing certain tasks.

To gain an understanding of the experience users have had with specific interface components from the prototype design, questions are created based on the Specific Displays → *Related events, Color, Icons, Saliency variations, Sensory modality, Textual Labels* sub-categories; and Specific Controls → *Appearance, Feedback, Operation, Sensory modalities* sub-categories.

Questions are also created expanding on the Contextual Knowledge → *Environment, Lexicon* sub-categories, to assess the frequency and nature of experience with different contexts and environments of operation as well as with the vocabulary used in the human-computer system. As mentioned before, a full example of a questionnaire developed with this procedure is provided in Appendix C.

The sample provided in the appendix for the two part survey instrument was developed over several iterations and pilot tested at the individual question (labels and wording) and the complete survey level. It lists all the categories and sub-categories in which each of the questions are based, highlighted in yellow. Options provided for the multiple choice questions (e.g., related to cabin locations) are intended to be exhaustive and were pilot tested as well. The administration of the questionnaire was pilot-tested with university undergrads, and their experiences used to determine a time of 1.5 hours to complete the two-part survey.

4.3 Analysis of required and current interface knowledge

Once the questionnaire is completed with participants from relevant user profiles, their answers are collected and organized with the Knowledge Taxonomy sub-categories used in its development (Interface Family Knowledge, Contextual Knowledge and Equipment Knowledge). Next, a comparative analysis of knowledge required (4.1) and current user knowledge (4.2) is conducted, for which we propose a guide below. In these sections, we proposed secondary analyses, to study mismatches between user and designer perceptions of what the priority tasks are as well as what the Interface Family label is. Nonetheless, the primary analysis that should be conducted is the assessment of the Knowledge Gap and is described in the current section.

Our proposed guide starts by assessing the knowledge gap on knowledge required about displays. Items compiled in the Knowledge Inventory (Appendix A) related to displays (Specific Displays Knowledge) can be compared with current knowledge questionnaire answers based on particular sub-categories from the Specific Displays and Interface Family → *Common displays* sub-categories, as depicted in Figure 6.

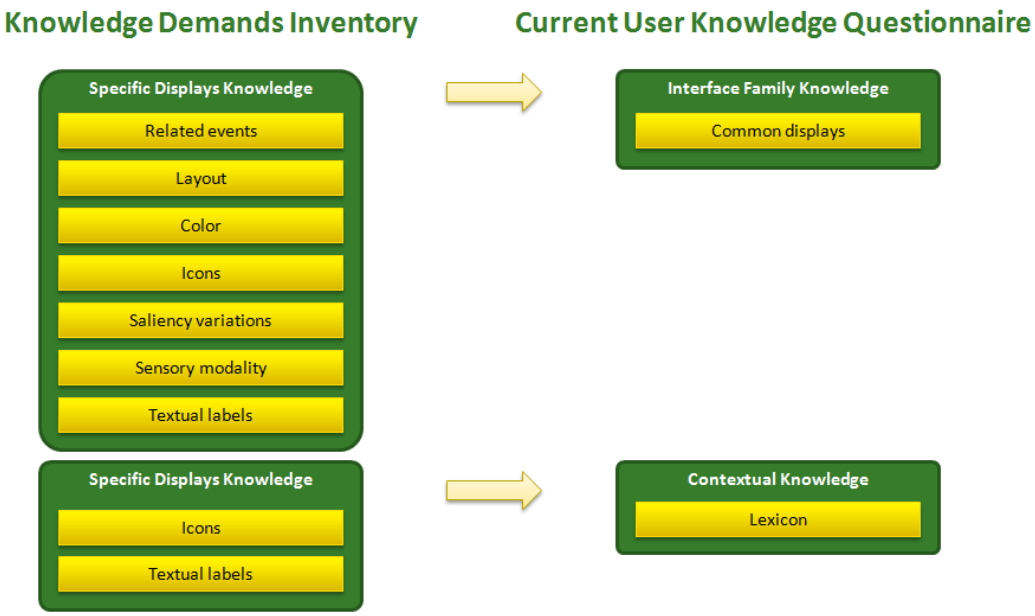


Figure 6. Assessing the knowledge gap for displays knowledge.

Next, the knowledge gap is evaluated on knowledge about controls. The Knowledge Inventory entries under the Specific Controls Knowledge category can be compared with current knowledge questionnaire answers to questions based on particular sub-categories in the Specific controls and Interface Family → *Common controls* categories, as shown in Figure 7.

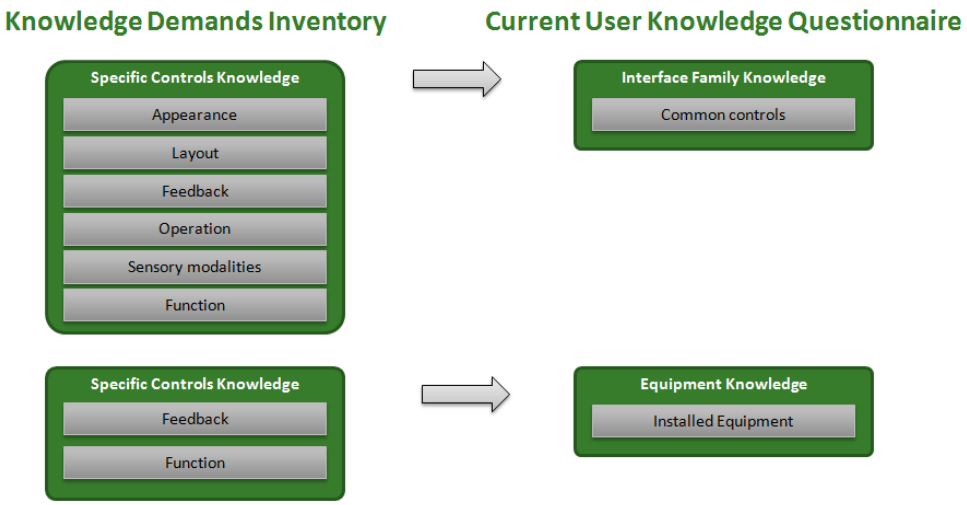


Figure 7. Assessing the knowledge gap for controls knowledge.

Similar to the previous assessments, the knowledge gap assessment can also be conducted for knowledge required about procedures required by an interface. Knowledge captured in the Knowledge Inventory under the Specific Procedures Knowledge categories can be compared with answers to questions based on the sub-categories in the Specific Procedures, Interface Family and Contextual knowledge categories, shown in Figure 8.

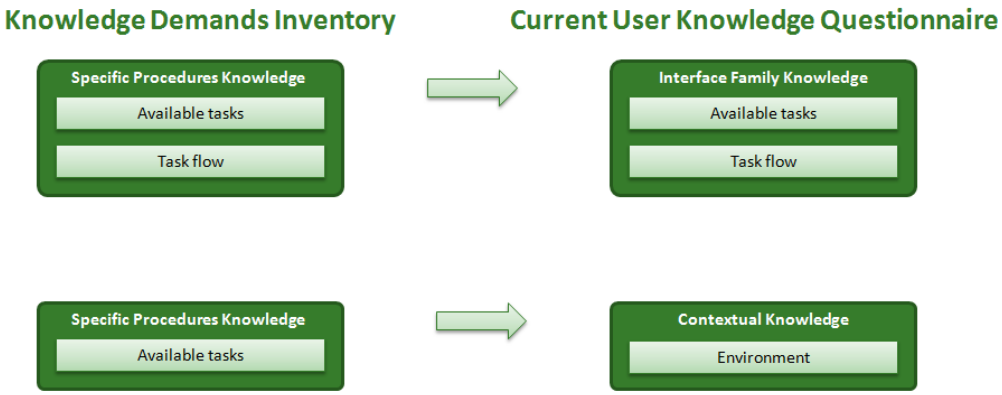


Figure 8. Assessing the knowledge gap for procedures knowledge.

It is up to researchers and designers (and their goals) to determine the specific method with which to conduct the comparisons of required knowledge and questionnaire responses described above. The assessment can be conducted quantitatively, with a numerical measure of the knowledge gap for each category and sub-categories (e.g. individual and/or summary scores). Additionally, the assessment can be

conducted qualitatively to identify salient themes and describe topic areas where current user knowledge is insufficient or to highlight significant trends such as current knowledge that contradicts required interface knowledge. A combination of these qualitative and quantitative assessments can provide great inputs to user interface design and evaluation activities such as walking a user through a novel interface or pilot testing a prototype design.

Further studies that build on the proposed guide are required to develop more detailed procedures and recommendations to conduct Knowledge Gap Assessments in a time and cost-effective manner. The proposed guide and support materials were based on a scientific foundation and serve as a starting point to these efforts.

5. References

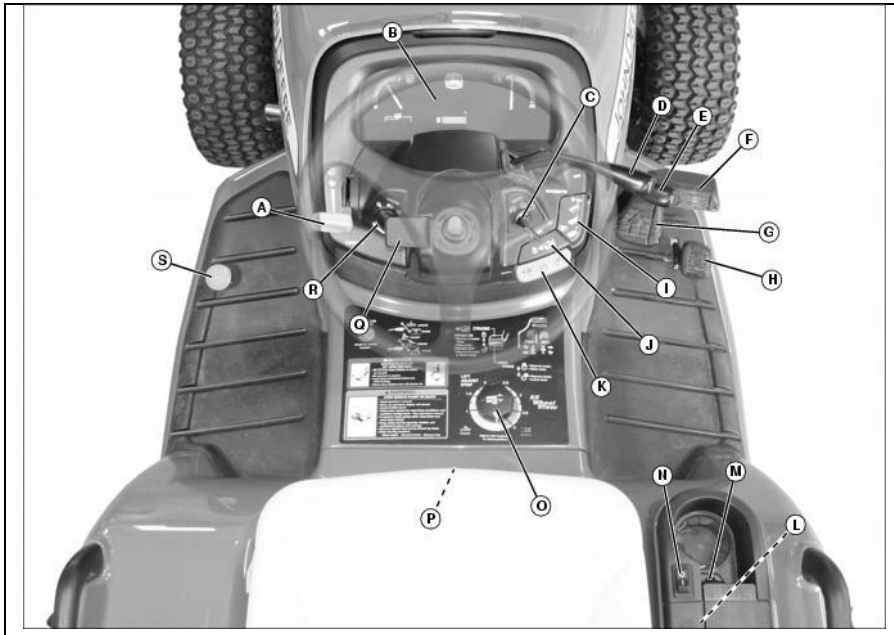
O'Brien, M. A., Rogers, W. A., & Fisk, A. D. (2010). *Developing an organizational model for intuitive design.* (HFA-TR-1001). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Serrano Baquero, D., & Rogers, W. A. (2010). *Knowledge and intuitive interface design: Developing a knowledge taxonomy* (HFA-TR-1004). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Appendix A. Materials used to create required JD X749 Ultimate Tractor Knowledge Inventory

Taken from product catalog: http://www.deere.com/en_US/homeowners/online_brochures/rle_literature/static/select_series_zmags.html

Taken from operator's manual: http://manuals.deere.com/cceomview/OMM157071_K7/Output/Index.html?tM=HO



Key	Description	Key	Description
A	Throttle Lever	K	Park Brake Lock
B	Instrument Panel (Gauges and Indicator Lights)	L	4-Wheel Drive (MFWD) Lever (If Equipped)
C	Key Switch	M	12V Accessory Outlet
D	Hydraulic Control Lever, Upper	N	12V Accessory Outlet Switch
E	Hydraulic Control Lever, Lower	O	Mower Height Control Knob
F	Brake Pedal	P	Seat Slide Lever
G	Forward Control Pedal	Q	Tilt Steering Lever
H	Reverse Control Pedal	R	Light Switch
I	PTO/RIO Switch	S	Traction Assist Pedal
J	Cruise Control Switch		

Using Mower Height Control Knob

Use mower height control knob (A) to adjust mower cutting height, and lock mower deck lift arms in raised position. See your mower deck operator's manual for instructions.

IMPORTANT: Avoid damage! To avoid machine damage when operating without a mower deck, fully raise mower deck lift arms and turn mower height control knob clockwise to highest setting to lock lift arms in raised position.

Using Park Brake

Locking Park Brake

CAUTION: Avoid injury! Children or bystanders may attempt to move or operate an unattended machine.

Always lock the park brake and remove the key before leaving the machine unattended.

MX13638

1. Fully depress brake pedal (A).
2. Pull park brake latch (B) up to lock park brake.
3. Release brake pedal and then park brake latch. Pedal should stay down and park brake latch should stay up in locked position.

Unlocking Park Brake

1. Fully depress brake pedal.
2. Push park brake latch down.
3. Release brake pedal. Pedal should come up to operating position.

Using Key Switch

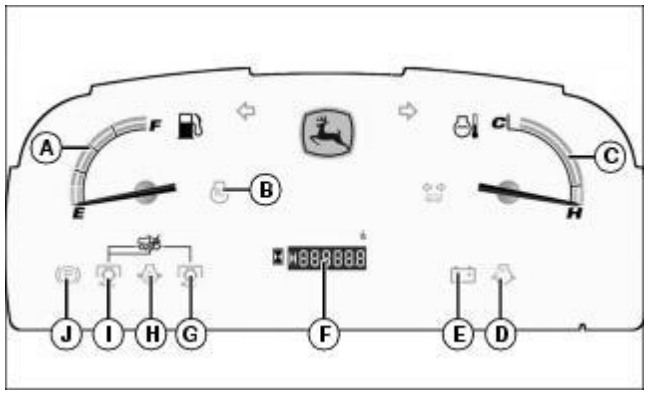
MX39542

A - Stop (Off)

B - Run

C - Start (Crank)

Using Indicator Lights



A - Fuel Gauge - indicates fuel level.

B - Engine Preheat Light - will come on for up to 8 seconds when starting engine. If engine has been run and then cooled, the time may be less.

C - Coolant Temperature Gauge - indicates temperature of cooling system. If needle on gauge reaches red range, the engine is overheating. If PTO is engaged, it will automatically shut off.

D - Air Restriction Indicator Light - will come on if air restriction indicator shows that air cleaner requires service.

E - Battery Discharge Indicator Light - will come on when there is no alternator output. If indicator comes on during operation, stop engine and perform appropriate service.

F - Hour Meter - shows number of hours engine has run. Check hour meter daily, and see periodic service required chart located under hood for service requirements.

G and I - PTO Indicator Lights - will come on when mid/front and/or rear PTO is engaged. Light will blink when Reverse Implement Option (RIO) is engaged.

H - Oil Pressure Indicator Light - will come on when engine oil pressure is too low. If indicator comes on during operation, stop engine and perform appropriate service. This is an indication that the engine is low on oil.

J - Park Brake Light - will come on when park brake is set.

If engine is overheated, disengage PTO, let engine cool at idle speed until needle returns to green range. Shut off engine and clean air intake screens and radiator screen.

Starting the Engine

NOTE: You must depress brake pedal, or lock park brake, before you can start engine. Be sure PTO/RIO switch is off.

1. Open fuel shut-off valve.

2. Lock park brake or depress brake pedal.

3. Push throttle lever up to between 1/2 and fast position.

4. Turn key to run position.

5. Check indicator lights:

• Oil pressure indicator light will be ON.

• Battery discharge indicator light will be ON.

• Engine preheat indicator light will come on and go out within approximately 8 seconds. If engine has been run and then cooled, the time may be less. Wait for indicator to go out before cranking engine.

6. Turn key to start position:

• Crank engine.

• If engine does not start within 5 seconds, turn key to stop position and wait 10 seconds.

• Crank engine again for 5 seconds.

Repeat this procedure if necessary.

IMPORTANT: Avoid damage! Unnecessary engine idling may cause engine damage. Excessive idling can cause engine overheating, carbon build-up, and poor performance.

7. As soon as engine starts, release key. The key will return to run position and all indicator lights should be off. If a light does not go off, stop engine and perform appropriate service.

Using Reverse Implement Option (RIO)

CAUTION: Avoid injury! Rotating blades are dangerous. Children or bystanders may be injured by run over and rotating blades.

Before backing up, carefully check the area around the machine.

NOTE: Backing up while mower is engaged is strongly discouraged. The Reverse Implement Option should be used only when operating another attachment or when operator deems it necessary to reposition machine with mower engaged.

1. Stop machine forward travel with attachment engaged.

2. Look behind machine to be sure there are no bystanders.

NOTE: If attachment stops while repositioning machine, return PTO/RIO switch to off position. Begin again with Step 2 in procedure.

MX22575, MX39639

3. Lift and hold PTO/RIO switch (A) up past the PTO engagement position to activate

Using Traction Assist

CAUTION: Avoid injury! Driving at high speeds with the traction assist engaged may result in loss of steering control. Do not engage traction assist or turn with the traction assist engaged while operating machine at high speeds or on slopes.

Traction assist is used to provide better traction when rear wheels start to slip. Do not use traction assist unless you are experiencing rear wheel slippage. Engaging traction assist will cause both rear wheels to drive equally to improve traction.

Engaging Traction Assist

IMPORTANT: Avoid damage! Using the traction assist function improperly can damage the transaxle:

- Reduce speed and allow drive wheels to rotate at same speed before engaging or disengaging traction assist.
- Disengage traction assist when driving on dry asphalt or concrete.
- Use traction assist only when necessary for improved ground engagement.

1. Stop or slow machine down.

2. Push down on traction assist pedal. Traction assist will remain engaged as long as pedal is depressed.

NOTE: Turning radius is increased when traction assist is engaged.

When brake pedal is depressed, traction assist will automatically engage.

Disengaging Traction Assist

1. Release traction assist pedal.

2. Once the load on the transmission is equalized and reduced, traction assist will

the reverse implement option while depressing reverse travel pedal slightly. Instrument panel PTO indicator light (B) will blink when RIO is engaged.

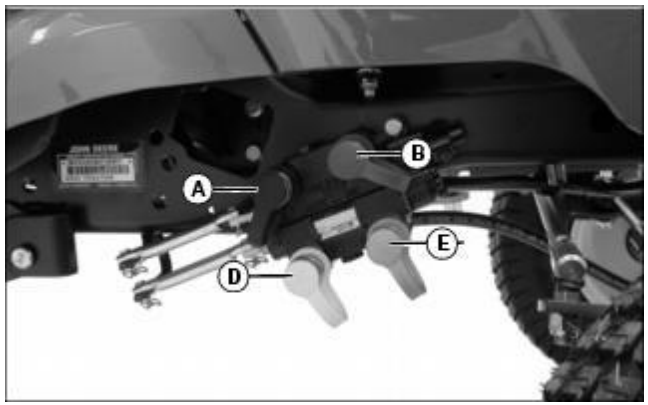
4. As machine begins to move backward, release PTO/RIO switch and reposition machine. Instrument panel PTO indicator light will stop blinking when switch is released.

5. Resume forward travel. The attachment should continue operating.

6. Repeat Steps 1 through 5 to reposition machine again.

Using Hydraulic Control Levers

NOTE: Hydraulic control levers operate differently depending on attachment. See attachment operator's manual before using hydraulic control levers with an attachment.



disengage automatically.

Using Cruise Control

Use cruise control when you want to maintain travel speed without having to hold the forward travel pedal down. Cruise control operates only for forward travel.

Operate machine in a large, open area to learn how cruise control works.

Engaging Cruise Control

1. Depress forward travel pedal until you reach desired travel speed.

2. Pull cruise latch up to lock cruise control.

3. Remove foot from forward travel pedal.

4. Release cruise latch.

Disengaging Cruise Control

1. Depress forward travel pedal or depress brake pedal.

Using 4-Wheel Drive (MFWD)

NOTE: Use four-wheel drive when more traction is needed. Tires will wear faster if four-wheel drive is always engaged.

Four-wheel drive enables the power train to drive all four wheels for improved traction on difficult ground conditions. The mechanical front wheel drive system can be engaged and disengaged on-the-go with light loads and on low-traction surfaces.

CAUTION: Avoid injury! Use extra caution when driving on slopes. To increase traction and provide four-wheel braking, engage mechanical front wheel drive (MFWD) when driving on slopes. Be aware that MFWD can improve access to

MX39015

When attachment hydraulic hoses are connected to couplers (A) (black) and (B) (green), push lower hydraulic control lever (C) forward to divert fluid to coupler (A) and return through coupler (B). Pull lever backward to divert fluid to coupler (B) and return through coupler (A). Push lever to the full forward or float position to remove pressure in both lines and allow fluid to flow back and forth between lines. Lever should return to neutral position when released.

When attachment hydraulic hoses are connected to couplers (D) (yellow) and (E) (silver), push upper hydraulic control lever (F) forward to divert fluid to coupler (D) and return through coupler (E). Pull lever backward to divert fluid to coupler (E) and return through coupler (D). Lever should return to neutral position when released.

NOTE: When not using lower hydraulic control lever, periodically move lever back and forth to maintain lubrication. Be sure lever is returned to middle (neutral) position and not locked in forward (float) position.

dangerously sloped terrain, thereby increasing the possibility of tip over.

To improve braking on sloped, icy, wet, or graveled surfaces, engage the MFWD. Add ballast to the tractor and travel at a reduced speed to avoid skidding and loss of steering control.

Ballasting

When operating in 4WD without a mower deck installed on machine, it is recommended you install rear wheel weights to increase stability:

• Install minimum of one BM17976 Weight Kit on each rear wheel.

Using 2WD/4WD Lever

MX13569

1. Move 2WD/4WD lever (A) forward to engage two-wheel drive.

2. Move 2WD/4WD lever (A) rearward to engage four-wheel drive.

Using the PTO (Power-Take-Off)

NOTE: Any operating attachment should stop as the reverse travel pedal or brake pedal is depressed with attachment engaged. Prior to operating the PTO, see Using Reverse Implement Option (RIO) in this section.

This machine is equipped with a 2000 rpm mid PTO.

Always operate engine at maximum speed when PTO is engaged.

Engaging PTO

1. Reduce travel speed or stop machine.

2. After engine has warmed, move throttle lever up to maximum engine speed.

MX22575, MX39619

3. Pull PTO/RIO switch (A) up. Instrument panel PTO indicator light(s) (B) will come on when PTO is engaged.

Disengaging PTO

NOTE: If reverse travel pedal or brake pedal is depressed, PTO will disengage.

1. Push PTO/RIO switch down to disengage PTO. Instrument panel PTO indicator light(s) will go out.

Appendix B. John Deere X749 Ultimate Tractor Required Knowledge Inventory

Specific Interface Knowledge	**Benchmark Tasks**		
Specific Displays	**Start-up Tractor**	**Use mower going forward**	**Use mower going in reverse**
Color	Red/Green range for engine temperature Indicator light color	Red/Green range for engine temperature Indicator light color	Indicator light color
Icons	Oil pressure indicator light Battery discharge indicator light Engine preheat indicator light PTO/RIO switch icons Stop/Run/Start icons in Key switch	PTO/RIO switch icons Throttle lever icons (rabbit, turtle) Engine temperature gauge icon PTO indicator light Forward/backward icons in pedals	PTO/RIO switch icons PTO indicator light Forward/backward icons in pedals
Layout	Indicator lights panel above steering wheel Above and around key switch	Indicator lights panel above steering wheel	Indicator lights panel above steering wheel
Saliency variations	Engine preheat indicator goes on, after 8 seconds, turns off.		PTO light in indicator panel blinks when RIO feature is engaged.
Sensory modality	Visual (lights)	Visual (lights)	Visual (lights)
Textual labels	Start, Stop Mower/PTO switch label	Engine temperature (H, C) Mower/PTO switch label	Mower/PTO switch label
Related event	Engine preheat light OFF -> Ready to crank engine All lights OFF -> Startup successful Park brake light ON -> park brake engaged	Engine temp. gauge in green range-> engine is warm PTO indicator lights (2) ON -> PTO engaged	PTO light blinks -> RIO feature is engaged PTO light back to ON -> RIO feature is disengaged
Specific Controls	**Start-up Tractor**	**Use mower going forward**	**Use mower going in reverse**
Appearance	Pedal, Latch, Lever, Key-Knob, Switch	Pedal, Lever, Switch, Knob, Wheel	Pedal, Switch, Wheel
Feedback	Park brake light on when park brake is set PTO/RIO light off when PTO/RIO deactivated Oil pressure, battery discharge, engine preheat lights on when key is set to “run” Key switch clicks into one of three positions	PTO/RIO light ON when PTO/RIO activated	PTO/RIO light blinks when RIO activated
Function	Park brake latch: parking brake on/off PTO/RIO switch: PTO/RIO on/off Throttle lever: increase/decrease engine rpm Key: off/run/start engine settings	PTO/RIO switch: PTO/RIO on/off Throttle lever: increase/decrease engine rpm Mower height knob: adjust mower cutting height Forward travel pedal: move tractor	PTO/RIO switch: PTO/RIO on/off Backward travel pedal: move tractor back
Layout	Controls behind and below steering wheel Move forward/braking pedals right side Accessory controls under right elbow	Throttle controls left of steering wheel PTO controls lower right of steering wheel Move forward pedals right side	PTO controls lower right of steering wheel Move forward pedals right side

	Seat slide control under seat	Mower height knob below steering wheel	
Operation	Press, Pull, Push, Turn	Press, Pull, Push, Turn	Push, Pull-and-hold, Turn
Sensory modality	Somatosensory	Somatosensory	Somatosensory
Specific Procedures	**Start-up Tractor**	**Use mower going forward**	**Use mower going in reverse**
Available tasks	Start-up tractor Use mower going forward Use mower going in reverse Use cruise control, traction assist, four-wheel drive		
Task flow	Set parking brake Increase throttle to between ½ and fast positions Turn key to "run" position Check indicator lights (oil pressure, battery discharge ON; engine preheat OFF after 8 seconds) Turn key to "start" position When engine starts, release key Check indicator lights (all lights OFF)	Reduce travel speed Increase throttle to maximum position Pull PTO/RIO switch up Check indicator lights (PTO/RIO lights ON) Move forward to mow	Stop machine Pull PTO/RIO switch up and hold to activate RIO option Press backward travel pedal slightly Check indicator lights (PTO/RIO light blinking) Reposition machine with steering wheel Release PTO/RIO switch
Interface modes	Brake or Parking brake activated/deactivated, allows/blocks engine start	Activated implement stops when brake/reverse pedals are pushed	PTO/RIO switch activated, RIO activated

Appendix C. Current User Knowledge Questionnaire Sample

Part 1 – Knowledge about Motor Vehicles

The purpose of this set of questions is to help us get an understanding of the knowledge you have about driving a Motor Vehicle and how you would use it to drive a new or unfamiliar one. There are not right or wrong answers, you will only be asked in this section about the knowledge you have about motor vehicles, even if you have not had experience with some of them. Please answer all questions as indicated in each section, and thinking about motor vehicles in general rather than a specific make or model.

What do we mean by Motor Vehicle? *A motor vehicle is a land-based, wheeled means of transportation and productivity propelled by an engine and driven by a human.*

Section Objective: Gain understanding of the most accessible knowledge that participants have about different types of motor vehicles, that can be used to approach John Deere X749 tractors for the first time. This section focuses on knowledge about goals, common tasks and the sequences of steps required to complete those tasks. Answers from this section can be traced to a type of motor vehicle to study knowledge transfer.

Interface Family Knowledge / Family name

1.	What words would you use to describe the motor vehicle pictured in Figure 1? (please provide 5 descriptive words or phrases below)

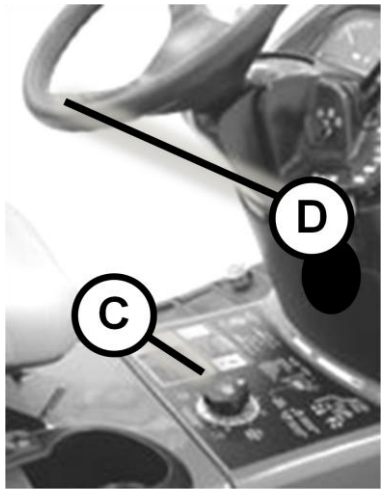
Figure 1

a.
b.
c.
d.
e.

2. What words would you use to describe the controls pictured below? (Continues in the next page…)

a:

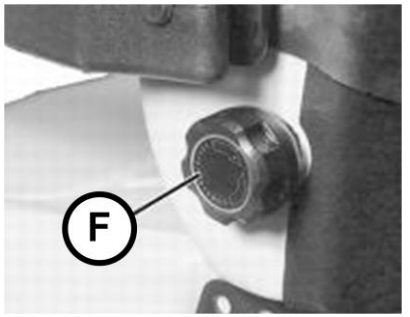
b:



c:

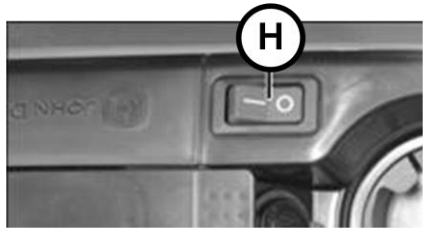
d:

e:



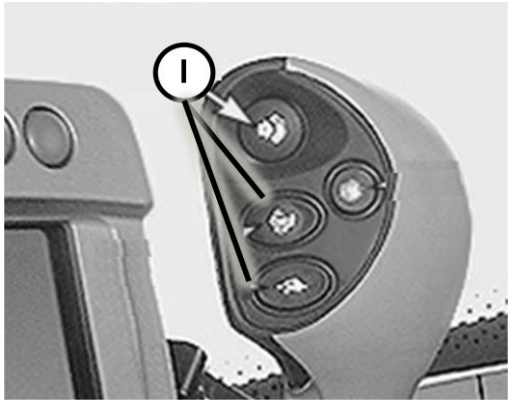
f:

g:

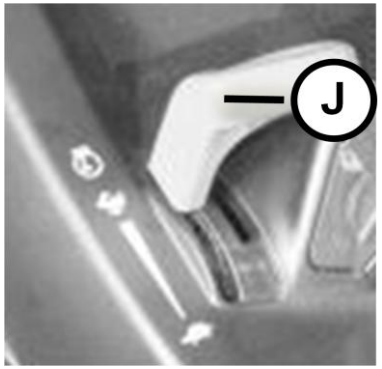


h:

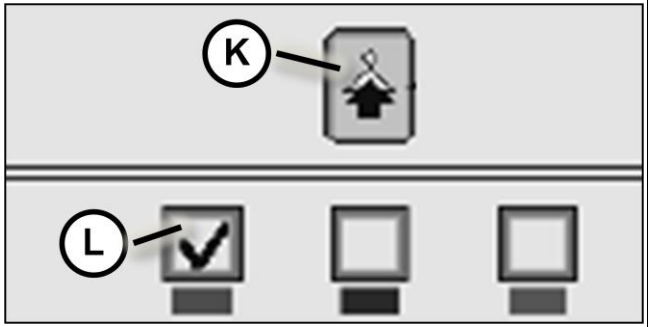
2. What words would you use to describe the controls pictured below? (Continued from previous page…)



i:

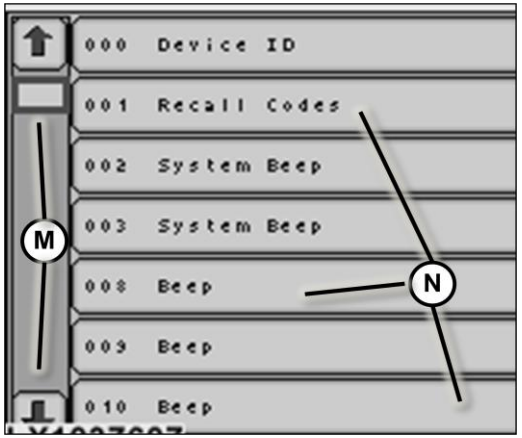


j:



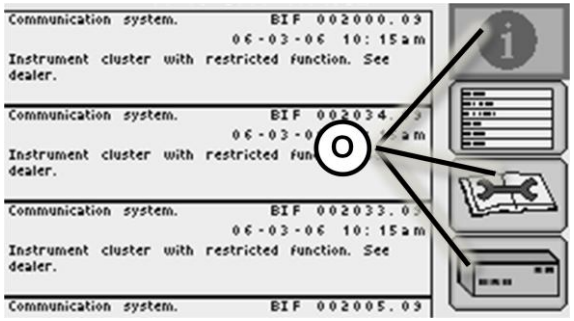
k:

l:



m:

n:



o:

Interface Family Knowledge / User goals

3. To the best of your knowledge, which of these purposes are motor vehicles well suited for? (Select all that apply)

Agriculture	Business, commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
○	○	○	○	○	○	○	○

Interface Family Knowledge / Available tasks

4. To the best of your knowledge, which of these tasks can be performed with motor vehicles? (Select all that apply)

Drive forward	Drive backward	Hook up accessory*	Hook up a trailer	Diagnosing problems w/ controls	Diagnosing problems w/ accessory*	Turn on accessory*	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
○	○	○	○	○	○	○	○	○	○	○

* What do we mean by accessory? *Accessory in a motor vehicle refers to vehicle components or features that can be installed, turned on, turned off or that can experience functioning problems.*

Interface Family Knowledge / Task flow

5. To the best of your knowledge, what steps would you follow to complete the tasks specified below, starting with the vehicle in Figure 2 powered off?

Figure 2

Task a: Turn vehicle on
Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:

Task b: Hook-up a mower accessory and mow driving forward
Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:

Task c: Hook-up a mower accessory and mow driving backward
Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:

Section Objective: Gain understanding of the most accessible knowledge participants have about 1) displays (the information they communicate, where and how to find them) and 2) controls (what they do, how to use them, where and how to find them) used to interact with a motor vehicle. Variations in answers from this section are expected to be influenced by specific makes and models driven more than by vehicle type, they cannot be traced to a type of motor vehicle for the study of knowledge transfer.

We want to learn about your knowledge of displays in motor vehicles. Displays provide the driver information about the status of the motor vehicle through gauges, labels, lights, and sounds, among others.

Specific Displays Knowledge / Related events

6. To the best of your knowledge, which of these pieces of information is typically communicated through displays in motor vehicles? (Select all that apply)

Engine ready for startup	Engine overheating	Engine temperature OK	Engine start successful	Accessory* turned on	Accessory* turned off	Gas cap location	Accessory* problem
○	○	○	○	○	○	○	○

* What do we mean by accessory? *Accessory in a motor vehicle refers to vehicle components or features that can be installed, turned on, turned off or that can experience functioning problems.*

Specific Displays Knowledge / Color, Icons, Saliency variations, Sensory modality, Textual labels

7. To the best of your knowledge, which of these characteristics make displays noticeable in motor vehicles? (Select all that apply)

Flashing or blinking	Contrasting colors	Icons or symbols	Location of displays	Lights	Progress bars	Sounds	Text labels
○	○	○	○	○	○	○	○

Specific Displays Knowledge / Layout

8. To the best of your knowledge, in which of these locations in motor vehicles are displays typically located? (Select all that apply)

Instrument panel behind steering column	Mounted left of steering column	Mounted right of steering column	Mounted above instrument console	Mounted on windshield	Part of instrument console	Part of the steering wheel

We want to learn about your knowledge of controls in motor vehicles. Controls let the driver operate a motor vehicle through levers, knobs, buttons, and wheels, among others.

Specific Controls Knowledge / Appearance

9. To the best of your knowledge, which of these controls are typically found in motor vehicles? (Select all that apply)

Button	Lever	Pedal	Rotary dial	Screen* button	Screen* checkbox	Screen* list	Screen* scrollbar	Screen* tabs	Steering wheel	Switch	Voice control
○	○	○	○	○	○	○	○	○	○	○	○

* What do we mean by screen? *Screen refers to onboard computer systems found in motor vehicles that incorporate controls drawn on a screen. Examples of these are touch-screens or computers controlled with a dial.*

Specific Controls Knowledge / Layout

10. To the best of your knowledge, in which of these locations are controls typically located in motor vehicles? (Select all that apply)

Cabin floor	Instrument panel behind steering column	Mounted left of steering column	Mounted right of steering column	Mounted above instrument console	Mounted on windshield	Part of instrument console	Part of the steering wheel	Under seat
○	○	○	○	○	○	○	○	○

Specific Controls Knowledge / Feedback, Operation, Sensory modalities

11. To the best of your knowledge, which of these operations are typically used with motor vehicle controls? (Select all that apply)

Pull once	Pull-and-hold	Push once	Push-and-hold	Push-to-release	Turn	Turn-and-hold	Use voice
○	○	○	○	○	○	○	○

12. To the best of your knowledge, which of these events is a typical response to the use of a control in motor vehicles (Select all that apply)

Accessory* turned on	Accessory* turned off	Indicator light turns on	Indicator light turns off	Indicator light blinks	Sound from accessory*	Sound from controls panel
○	○	○	○	○	○	○

* What do we mean by accessory? *Accessory in a motor vehicle refers to vehicle components or features that can be installed, turned on, turned off or that can experience functioning problems.*

Section Objective: Gain understanding of the most accessible knowledge participants have about the context in which they use motor vehicles and how this context impacts its use.

Contextual Knowledge / Environment

13. To the best of your knowledge, in which of these conditions can motor vehicles be typically operated? (Select all that apply)

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

14. To the best of your knowledge, rate the typical difficulty of driving an automobile in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

15. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

16. To the best of your knowledge, rate the typical difficulty of driving an all-terrain vehicle (ATV) in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

17. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

18. To the best of your knowledge, rate the typical difficulty of driving a bus in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

19. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

20. To the best of your knowledge, rate the typical difficulty of driving a motorcycle in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined	Around	Around	Day	Night

											Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

21. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

22. To the best of your knowledge, rate the typical difficulty of driving a riding mower in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

23. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

24. To the best of your knowledge, rate the typical difficulty of driving a tractor in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

25. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

26. To the best of your knowledge, rate the typical difficulty of driving a truck in these conditions.

Grass	Sand	Mud	Gravel	Pavement	Rain	Hail	Sun	Fog	Lightning	Inclined surfaces	Around obstacles*	Around people	Day	Night
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) very easy **(2) easy** **(3) difficult** **(4) very difficult** **(X) I do not know**

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

27. Briefly explain your answer to the previous question, where you described contexts as (3) difficult and (4) very difficult to drive in:

Section Objective: Gain understanding of the most accessible knowledge that participants have about mechanical equipment and how it impacts motor vehicle operation.

Equipment Knowledge / Installed equipment

28. To the best of your knowledge, which of these mechanical components are typically found in the following motor vehicles? (Select all that apply)

Emergency lights	Engine oil	Headlights	Mower	Parking brake	Vehicle battery	Metal wheel rim	Rubber tire
○	○	○	○	○	○	○	○

29. To the best of your knowledge, which of these purposes are the following mechanical components typically used for? (Select all that apply)

Component	Agriculture	Commercial maintenance	Fun/Pleasure	Group transport	Home maintenance	Individual transport	Motorsport	Towing a load

				(2+ people)		**(1 person)**		
Emergency lights	○	○	○	○	○	○	○	○
Engine oil	○	○	○	○	○	○	○	○
Headlights	○	○	○	○	○	○	○	○
Mower	○	○	○	○	○	○	○	○
Parking brake	○	○	○	○	○	○	○	○
Vehicle battery	○	○	○	○	○	○	○	○
Vehicle wheel rim	○	○	○	○	○	○	○	○
Vehicle wheel tire	○	○	○	○	○	○	○	○

Part 2 – Experience with Motor Vehicles

The purpose of this set of questions is to help us get an understanding of the experience you have about driving a Motor Vehicle and how you use that experience to drive a new or unfamiliar Motor Vehicle. There are not right or wrong answers, because we are interested in learning about your personal experience driving motor vehicles. Please answer all questions as indicated in each section.

Section Objective: Gain understanding of the experience that participants have with certain types of motor vehicles, and tasks to identify the source for the knowledge they exhibited answering Part 1 of the questionnaire.

Interface Family Knowledge / Family name / User goals

1. Have you driven an automobile before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 4.

2. How often to do you drive an automobile for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

3. How often do you perform these tasks related to driving an automobile?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

4. Have you driven an all-terrain vehicle (ATV) before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 7.

5. How often to do you drive an all-terrain vehicle (ATV) for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

6. How often do you perform these tasks related to driving an all-terrain vehicle (ATV)?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

7. Have you driven a bus before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 10.

8. How often to do you drive a bus for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

9. How often do you perform these tasks related to driving a bus?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

10. Have you driven a motorcycle before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 13.

11. How often to do you drive a motorcycle for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

12. How often do you perform these tasks related to driving a motorcycle?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

13. Have you driven a riding mower before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 16.

14. How often to do you drive a riding mower for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

15. How often do you perform these tasks related to driving a riding mower?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice (2) yearly (3) monthly (4) every day (5) more than once a day

16. Have you driven a tractor before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 19.

17. How often to do you drive a tractor for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

18. How often do you perform these tasks related to driving a tractor?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

19. Have you driven a truck before? (select only one) ○ Yes ○ No

If you answered **No** to the previous question, skip to Question 22.

20. How often to do you drive a truck for these purposes?

Agriculture	Commercial maintenance	Fun/Pleasure	Group transport (2+ people)	Home maintenance	Individual transport (1 person)	Motorsport	Towing a load
☐	☐	☐	☐	☐	☐	☐	☐

(1) used only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

21. How often do you perform these tasks related to driving a truck?

Drive forward	Drive backward	Hook up accessory	Hook up a trailer	Diagnosing problems w/ control	Diagnosing problems w/ accessory	Turn on accessory	Turn on four-wheel drive	Turn on cruise control	Turn on traction assistance system	Turn vehicle on/off
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(1) performed only once or twice **(2) yearly** **(3) monthly** **(4) every day** **(5) more than once a day**

22. What training did you receive when you drove these motor vehicles for the first time? (Select all that apply)

Classroom training sessions	In-the-vehicle training by instructor	In-the-vehicle training by a peer	Operator Manual	Trial and error
○	○	○	○	○

Specific Displays Knowledge / Related events

23. How often do you see a display communicating these pieces of information while driving motor vehicles in general?

	Never	Seen only once or twice	Yearly	Monthly	Every day	More than once a day
Engine ready for startup	○	○	○	○	○	○
Engine overheating	○	○	○	○	○	○
Engine temperature OK	○	○	○	○	○	○
Engine start successful	○	○	○	○	○	○
Accessory turned on	○	○	○	○	○	○
Accessory turned off	○	○	○	○	○	○
Gas cap location	○	○	○	○	○	○
Accessory problem	○	○	○	○	○	○

Specific Displays Knowledge / Color, Icons, Saliency variations, Sensory modality, Textual labels

24. How often do you notice a display because of the following characteristics while driving motor vehicles in general?

	Never	Noticed only once or twice	Yearly	Monthly	Every day	More than once a day
Flashing or blinking	○	○	○	○	○	○
Contrasting colors	○	○	○	○	○	○
Icons or symbols	○	○	○	○	○	○
Location of displays	○	○	○	○	○	○
Lights	○	○	○	○	○	○
Progress bars	○	○	○	○	○	○
Sounds	○	○	○	○	○	○
Text labels	○	○	○	○	○	○

Specific Controls Knowledge / Appearance

25. How often do you use the following types of controls while driving motor vehicles in general?

	Never	Used only once or twice	Yearly	Monthly	Every day	More than once a day
Button	○	○	○	○	○	○
Lever	○	○	○	○	○	○
Pedal	○	○	○	○	○	○
Rotary dial	○	○	○	○	○	○
Screen* button	○	○	○	○	○	○

Screen*checkbox	○	○	○	○	○	○
Screen* list	○	○	○	○	○	○
Screen* scrollbar	○	○	○	○	○	○
Screen* tabs	○	○	○	○	○	○
Steering wheel	○	○	○	○	○	○
Switch	○	○	○	○	○	○
Voice control	○	○	○	○	○	○

* What do we mean by screen? *Screen refers to onboard computer systems found in motor vehicles that incorporate controls drawn on a screen. Examples of these are touch-screens or computers controlled with a dial.*

Specific Controls Knowledge / Feedback, Operation, Sensory modalities

26. How often do you use the following operations with controls while driving motor vehicles in general?

	Never	**Used only once or twice**	**Yearly**	**Monthly**	**Every day**	**More than once a day**
Pull once	○	○	○	○	○	○
Pull-and-hold	○	○	○	○	○	○
Push once	○	○	○	○	○	○
Push-and-hold	○	○	○	○	○	○
Push-to-release	○	○	○	○	○	○
Turn	○	○	○	○	○	○
Turn-and-hold	○	○	○	○	○	○
Use voice	○	○	○	○	○	○

27. How often do you see the following responses to the use of a control while driving motor vehicles in general?

	Never	Seen only once or twice	Yearly	Monthly	Every day	More than once a day
Accessory turned on	○	○	○	○	○	○
Accessory turned off	○	○	○	○	○	○
Indicator light turns on	○	○	○	○	○	○
Indicator light turns off	○	○	○	○	○	○
Indicator light blinks	○	○	○	○	○	○
Sound from accessory	○	○	○	○	○	○
Sound from controls panel	○	○	○	○	○	○

Contextual Knowledge / Environment

28. How often do you operate motor vehicles in general, in the following conditions?

	Never	Operated only once or twice	Yearly	Monthly	Every day	More than once a day
Grass	○	○	○	○	○	○
Sand	○	○	○	○	○	○
Mud	○	○	○	○	○	○
Gravel	○	○	○	○	○	○
Pavement	○	○	○	○	○	○
Rain	○	○	○	○	○	○

Hail	○	○	○	○	○	○
Sun	○	○	○	○	○	○
Fog	○	○	○	○	○	○
Lightning	○	○	○	○	○	○
Inclined surfaces	○	○	○	○	○	○
Around obstacles*	○	○	○	○	○	○
Around people	○	○	○	○	○	○
Day	○	○	○	○	○	○
Night	○	○	○	○	○	○

* What do we mean by obstacles? Obstacles are static elements that stand in the way of the circulation of a motor vehicle. Among others, they include: poles, posts, walls, trees.

Contextual Knowledge / Lexicon

29. Indicate if you have seen the representations pictured in Figure 3 below and what they typically mean.

Figure 9

Representation	Seen at least once? (choose one)		Specify the typical meaning for each representation below, or "I do not know"
A	○ Yes	○ No	○ I do not know
B	○ Yes	○ No	○ I do not know
C	○ Yes	○ No	○ I do not know

30. Indicate if you have seen the representations pictured in Figure 4 below and what they typically mean.

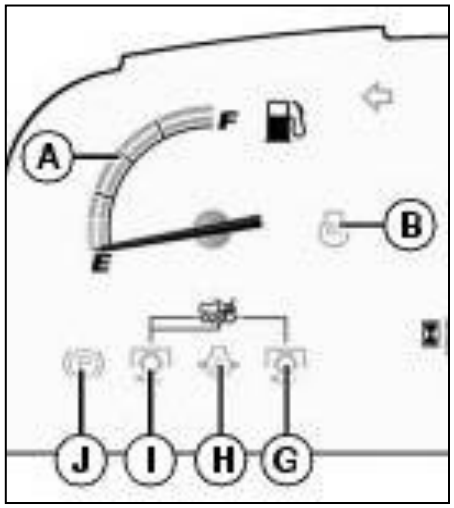


Figure 4

Representation	Seen at least once? (choose one)		Specify the typical meaning for each representation below, or "I do not know"
A	○ Yes	○ No	○ I do not know
B	○ Yes	○ No	○ I do not know
G	○ Yes	○ No	○ I do not know
H	○ Yes	○ No	○ I do not know
I	○ Yes	○ No	○ I do not know
J	○ Yes	○ No	○ I do not know

31. Indicate if you have seen the representations pictured in Figure 5 below and what they typically mean.

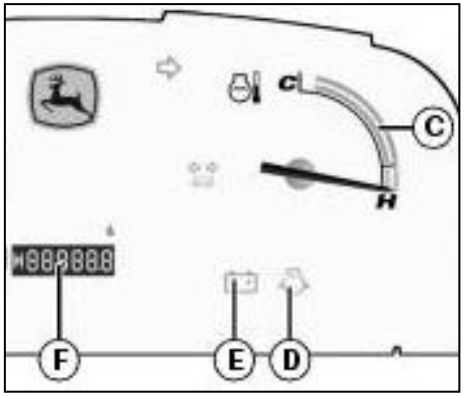


Figure 5

Representation	Seen at least once? (choose one)		Specify the typical meaning for each representation below, or "I do not know"
C	○ Yes	○ No	○ I do not know
D	○ Yes	○ No	○ I do not know
E	○ Yes	○ No	○ I do not know
F	○ Yes	○ No	○ I do not know