

# Package ‘DeclareDesign’

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**Title** Declare and Diagnose Research Designs

**Version** 1.0.0

**Description** Researchers can characterize and learn about the properties of research designs before implementation using `DeclareDesign`. Ex ante declaration and diagnosis of designs can help researchers clarify the strengths and limitations of their designs and to improve their properties, and can help readers evaluate a research strategy prior to implementation and without access to results. It can also make it easier for designs to be shared, replicated, and critiqued.

**Depends** R (>= 3.5.0), randomizr (>= 0.20.0), fabricatr (>= 0.10.0), estimatr (>= 0.20.0)

**Imports** rlang, generics, methods

**License** MIT + file LICENSE

**URL** <https://declaredesign.org/r/declaredesign/>,  
<https://github.com/DeclareDesign/DeclareDesign>

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---

cite\_design

*Obtain the preferred citation for a design*


---

**Description**

Obtain the preferred citation for a design

**Usage**

```
cite_design(design, ...)
```

**Arguments**

design            a design object created using the + operator  
 ...              options for printing the citation if it is a BibTeX entry

---

compare\_diagnoses      *Compare Diagnoses*

---

**Description**

Diagnose and compare designs.

**Usage**

```
compare_diagnoses(
  design1,
  design2,
  sims = 500,
  bootstrap_sims = 100,
  merge_by_estimator = TRUE,
  alpha = 0.05
)
```

**Arguments**

design1            A design or a diagnosis.  
 design2           A design or a diagnosis.  
 sims              The number of simulations, defaulting to 1000. *sims* may also be a vector indicating the number of simulations for each step in a design, as described for [simulate\\_design](#). Used for both designs.  
 bootstrap\_sims   Number of bootstrap replicates for the diagnosands to obtain the standard errors of the diagnosands, defaulting to 1000. Set to FALSE to turn off bootstrapping. Used for both designs. Must be greater or equal to 100.  
 merge\_by\_estimator   A logical. Whether to include estimator in the set of columns used for merging. Defaults to TRUE.  
 alpha             The significance level, 0.05 by default.

**Details**

The function `compare_diagnoses` runs a many-to-many merge matching by inquiry and term (if present). If `merge_by_estimator` equals TRUE, `estimator` is also included in the merging condition. Any diagnosand that is not included in both designs will be dropped from the merge.

**Value**

A list with a data.frame of compared diagnoses and both diagnoses.

**Examples**

```

design_a <- declare_model(N = 100,
                        U = rnorm(N),
                        Y_Z_0 = U,
                        Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)) +
declare_assignment(Z = complete_ra(N, prob = 0.5)) +
declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
declare_estimator(Y ~ Z, inquiry = "ATE")

design_b <- replace_step(
  design_a, step = "assignment",
  declare_assignment(Z = complete_ra(N, prob = 0.3)) )

comparison <- compare_diagnoses(design_a, design_b, sims = 40)

```

---

compare\_functions      *Compare two designs*

---

**Description**

Compare two designs

**Usage**

```

compare_designs(
  design1,
  design2,
  format = "ansi8",
  pager = "off",
  context = -1L,
  rmd = FALSE
)

compare_design_code(
  design1,
  design2,
  format = "ansi256",
  mode = "sidebyside",
  pager = "off",
  context = -1L,
  rmd = FALSE
)

compare_design_summaries(
  design1,
  design2,

```

```
    format = "ansi256",
    mode = "sidebyside",
    pager = "off",
    context = -1L,
    rmd = FALSE
)

compare_design_data(
  design1,
  design2,
  format = "ansi256",
  mode = "sidebyside",
  pager = "off",
  context = -1L,
  rmd = FALSE
)

compare_design_estimates(
  design1,
  design2,
  format = "ansi256",
  mode = "auto",
  pager = "off",
  context = -1L,
  rmd = FALSE
)

compare_design_inquiries(
  design1,
  design2,
  format = "ansi256",
  mode = "sidebyside",
  pager = "off",
  context = -1L,
  rmd = FALSE
)
```

### Arguments

design1	A design object, typically created using the + operator
design2	A design object, typically created using the + operator
format	Format (in console or HTML) options from <code>diffobj::diffChr</code>
pager	Pager option from <code>diffobj::diffChr</code>
context	Context option from <code>diffobj::diffChr</code> which sets the number of lines around differences that are printed. By default, all lines of the two objects are shown. To show only the lines that are different, set <code>context = 0</code> ; to get one line around differences for context, set to 1.

rmd	Set to TRUE use in Rmarkdown HTML output. NB: will not work with LaTeX, Word, or other .Rmd outputs.
mode	Mode options from diffobj::diffChr

## Examples

```
design1 <- declare_model(N = 100, u = rnorm(N), potential_outcomes(Y ~ Z + u)) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N, n = 75)) +
  declare_assignment(Z = complete_ra(N, m = 50)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

design2 <- declare_model(N = 200, U = rnorm(N),
  potential_outcomes(Y ~ 0.5*Z + U)) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N, n = 100)) +
  declare_assignment(Z = complete_ra(N, m = 25)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, .method = lm_robust, inquiry = "ATE")

compare_designs(design1, design2)
compare_design_code(design1, design2)
compare_design_summaries(design1, design2)
compare_design_data(design1, design2)
compare_design_estimates(design1, design2)
compare_design_inquiries(design1, design2)
```

---

DeclareDesign      *DeclareDesign package*

---

## Description

The four main types of functions are to declare a step, to combine steps into designs, and to manipulate designs and designers (functions that return designs).

## Design Steps

[declare\\_model](#) Model step  
[declare\\_inquiry](#) Inquiry step  
[declare\\_sampling](#) Data strategy step (sampling)  
[declare\\_assignment](#) Data strategy step (assignment)  
[declare\\_measurement](#) Data strategy step (measurement)  
[declare\\_estimator](#) Answer strategy step (Estimator)  
[declare\\_test](#) Answer strategy step (Testing function)

**Design Objects**

- + Add steps to create a design
- [redesign](#) Change design parameters
- [draw\\_data](#) Draw a simulated dataset
- [run\\_design](#) Draw one set of inquiry values and estimates
- [diagnose\\_design](#) Diagnose a design
- [cite\\_design](#) Cite a design

**Design Editing**

- [modify\\_design](#) Add, delete or replace a step
- [redesign](#) Modify local variables within a design (advanced)

**Designers**

- [expand\\_design](#) Generate designs from a designer
- designs** See also the DesignLibrary package for designers to use

---

declare\_assignment      *Declare Data Strategy: Assignment*

---

**Description**

Declare Data Strategy: Assignment

**Usage**

```
declare_assignment(..., handler = assignment_handler, label = NULL)
assignment_handler(data, ..., legacy = FALSE)
```

**Arguments**

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step
data	A data.frame.
legacy	Use the legacy randomizr functionality. This will be disabled in future; please use legacy = FALSE.

**Value**

A function that takes a data.frame as an argument and returns a data.frame with assignment columns appended.

**Examples**

```

# declare_assignment in use
## Two-arm randomized experiment
design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ 0.2 * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N = N, n = 200)) +
  declare_assignment(Z = complete_ra(N = N, m = 100)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

# Set up population to assign
model <- declare_model(
  villages = add_level(
    N = 30,
    N_households = sample(c(50:100), N, replace = TRUE)
  ),
  households = add_level(
    N = N_households,
    N_members = sample(c(1, 2, 3, 4), N,
                      prob = c(0.2, 0.3, 0.25, 0.25), replace = TRUE)
  ),
  individuals = add_level(
    N = N_members,
    age = sample(18:90, N, replace = TRUE),
    gender = rbinom(n = N, size = 1, prob = .5)
  )
)

# Assignment procedures
## Complete random assignment
design <-
  model +
  declare_assignment(Z = complete_ra(N = N, m = 1000))

## Cluster random assignment
design <-
  model +
  declare_assignment(Z = cluster_ra(clusters = villages,
                                   n = 15))

## Block and cluster random assignment
design <-
  model +
  declare_assignment(Z = block_and_cluster_ra(
    blocks = villages,
    clusters = households,

```



```

      block_m = rep(20, 30)
    ))

## Block random assignment
design <-
  model +
  declare_assignment(Z = block_ra(blocks = gender, m = 100))

## Block random assignment using probabilities
design <-
  model +
  declare_assignment(Z = block_ra(blocks = gender,
                                block_prob = c(1 / 3, 2 / 3)))

## Factorial assignment
design <-
  model +
  declare_assignment(Z1 = complete_ra(N = N, m = 100),
                    Z2 = block_ra(blocks = Z1))

## Assignment using functions outside of randomizr
design <-
  model +
  declare_assignment(Z = rbinom(n = N, size = 1, prob = 0.35))

```

---

declare_design	<i>Declare a design</i>
----------------	-------------------------

---

## Description

Declare a design

## Usage

```
## S3 method for class 'dd'
lhs + rhs
```

## Arguments

lhs	A step in a research design, beginning with a function that defines the model. Steps are evaluated sequentially. With the exception of the first step, all steps must be functions that take a <code>data.frame</code> as an argument and return a <code>data.frame</code> . Steps are declared using the <code>declare_</code> functions, i.e., <a href="#">declare_model</a> , <a href="#">declare_inquiry</a> , <a href="#">declare_sampling</a> , <a href="#">declare_assignment</a> , <a href="#">declare_measurement</a> , <a href="#">declare_estimator</a> , and <a href="#">declare_test</a> .
rhs	A second step in a research design

**Value**

a design

**Examples**

```

design <-
  declare_model(
    N = 500,
    U = rnorm(N),
    potential_outcomes(Y ~ Z + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N, n = 250)) +
  declare_assignment(Z = complete_ra(N, m = 25)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

dat <- draw_data(design)
head(dat)

run_design(design)

# You may wish to have a design with only one step:

design <- declare_model(N = 500, noise = rnorm(N)) + NULL

## Not run:
diagnosis <- diagnose_design(design)

summary(diagnosis)

## End(Not run)

```

---

declare_estimator	<i>Declare estimator</i>
-------------------	--------------------------

---

**Description**

Declares an estimator which generates estimates and associated statistics.

Use of `declare_test` is identical to use of `declare_estimator`. Use `declare_test` for hypothesis testing with no specific inquiry in mind; use `declare_estimator` for hypothesis testing when you can link each estimate to an inquiry. For example, `declare_test` could be used for a K-S test of distributional equality and `declare_estimator` for a difference-in-means estimate of an average treatment effect.

**Usage**

```

declare_estimator(
  ...,
  handler = label_estimator(method_handler),
  label = "estimator"
)

declare_estimators(
  ...,
  handler = label_estimator(method_handler),
  label = "estimator"
)

label_estimator(fn)

method_handler(
  data,
  ...,
  .method = estimatr::lm_robust,
  .summary = tidy_try,
  model,
  model_summary,
  term = FALSE
)

```

**Arguments**

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step
fn	A function that takes a data.frame as an argument and returns a data.frame with the estimates, summary statistics (i.e., standard error, p-value, and confidence interval), and a term column for labeling coefficient estimates.
data	a data.frame
.method	A method function, e.g. lm or glm. By default, the method is the <a href="#">lm_robust</a> function from the <a href="#">estimatr</a> package, which fits OLS regression and calculates robust and cluster-robust standard errors.
.summary	A method-in data-out function to extract coefficient estimates or method summary statistics, such as <a href="#">tidy</a> or <a href="#">glance</a> . By default, the DeclareDesign method summary function <a href="#">tidy_try</a> is used, which first attempts to use the available tidy method for the method object sent to method, then if not attempts to summarize coefficients using the <code>coef(summary())</code> and <code>confint</code> methods. If these do not exist for the method object, it fails.
model	Deprecated argument. Use <code>.method</code> instead.
model_summary	Deprecated argument. Use <code>.summary</code> instead.

**term** Symbols or literal character vector of term that represent quantities of interest, i.e. Z. If FALSE, return the first non-intercept term; if TRUE return all term. To escape non-standard-evaluation use !!.

## Details

declare\_estimator is designed to handle two main ways of generating parameter estimates from data.

In declare\_estimator, you can optionally provide the name of an inquiry or an object created by `declare_inquiry` to connect your estimate(s) to inquiry(s).

The first is through `label_estimator(method_handler)`, which is the default value of the handler argument. Users can use standard method functions like `lm`, `glm`, or `iv_robust`. The methods are summarized using the function passed to the `summary` argument. This will usually be a "tidier" like `broom::tidy`. The default summary function is `tidy_try`, which applies a tidy method if available, and if not, tries to make one on the fly.

An example of this approach is:

```
declare_estimator(Y ~ Z + X, .method = lm_robust, .summary = tidy, term = "Z", inquiry = "ATE")
```

The second approach is using a custom data-in, data-out function, usually first passed to `label_estimator`. The reason to pass the custom function to `label_estimator` first is to enable clean labeling and linking to inquiries.

An example of this approach is:

```
my_fun <- function(data){ with(data, median(Y[Z == 1]) - median(Y[Z == 0])) }
declare_estimator(handler = label_estimator(my_fun), inquiry = "ATE")
```

`label_estimator` takes a data-in-data out function to `fn`, and returns a data-in-data-out function that first runs the provided estimation function `fn` and then appends a label for the estimator and, if an inquiry is provided, a label for the inquiry.

## Value

A function that accepts a data.frame as an argument and returns a data.frame containing the value of the estimator and associated statistics.

## Examples

```
# Setup for examples
design <-
  declare_model(
    N = 500,
    gender = rbinom(N, 1, 0.5),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ rbinom(
      N, 1, prob = pnorm(0.2 * Z + 0.2 * gender + 0.1 * Z * gender + U)
    ))
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
```

```

declare_sampling(S = complete_rs(N = N, n = 200)) +
declare_assignment(Z = complete_ra(N = N, m = 100)) +
declare_measurement(Y = reveal_outcomes(Y ~ Z))

# default estimator is lm_robust with tidy summary
design_0 <-
  design +
  declare_estimator(Y ~ Z, inquiry = "ATE")

run_design(design_0)

# Linear regression using lm_robust and tidy summary
design_1 <-
  design +
  declare_estimator(
    formula = Y ~ Z,
    .method = lm_robust,
    .summary = tidy,
    term = "Z",
    inquiry = "ATE",
    label = "lm_no_controls"
  )

run_design(design_1)

# Use glance summary function to view model fit statistics
design_2 <-
  design +
  declare_estimator(.method = lm_robust,
                    formula = Y ~ Z,
                    .summary = glance)

run_design(design_2)

# Use declare_estimator to implement custom answer strategies
my_estimator <- function(data) {
  data.frame(estimate = mean(data$Y))
}

design_3 <-
  design +
  declare_inquiry(Y_bar = mean(Y)) +
  declare_estimator(handler = label_estimator(my_estimator),
                    label = "mean",
                    inquiry = "Y_bar")

run_design(design_3)

# Use `term` to select particular coefficients
design_4 <-
  design +
  declare_inquiry(difference_in_cates = mean(Y_Z_1[gender == 1] - Y_Z_0[gender == 1]) -
                  mean(Y_Z_1[gender == 0] - Y_Z_0[gender == 0])) +

```

```

declare_estimator(Y ~ Z * gender,
                  term = "Z:gender",
                  inquiry = "difference_in_cates",
                  .method = lm_robust)

run_design(design_4)

# Use glm from base R
design_5 <-
  design +
  declare_estimator(Y ~ Z + gender,
                    family = "gaussian",
                    inquiry = "ATE",
                    .method = glm)

run_design(design_5)

# If we use logit, we'll need to estimate the average marginal effect with
# margins::margins. We wrap this up in function we'll pass to model_summary

library(margins) # for margins
library(broom) # for tidy

tidy_margins <- function(x) {
  tidy(margins(x, data = x$data), conf.int = TRUE)
}

design_6 <-
  design +
  declare_estimator(
    Y ~ Z + gender,
    .method = glm,
    family = binomial("logit"),
    .summary = tidy_margins,
    term = "Z"
  )

run_design(design_6)

# Multiple estimators for one inquiry

design_7 <-
  design +
  declare_estimator(Y ~ Z,
                    .method = lm_robust,
                    inquiry = "ATE",
                    label = "OLS") +
  declare_estimator(
    Y ~ Z + gender,
    .method = glm,
    family = binomial("logit"),
    .summary = tidy_margins,
    inquiry = "ATE",

```

```

    term = "Z",
    label = "logit"
  )

run_design(design_7)

```

---

declare_inquiry	<i>Declare inquiry</i>
-----------------	------------------------

---

### Description

Declares inquiries, or the inferential target of interest. Conceptually very close to "estimand" or "quantity of interest".

### Usage

```

declare_inquiry(..., handler = inquiry_handler, label = "inquiry")

declare_inquiries(..., handler = inquiry_handler, label = "inquiry")

declare_estimand(...)

declare_estimands(...)

inquiry_handler(data, ..., subset = NULL, term = FALSE, label)

```

### Arguments

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step
data	a data.frame
subset	a subset expression
term	TRUE/FALSE

### Details

For the default diagnosands, the return value of the handler should have inquiry and estimand columns.

If term is TRUE, the names of ... will be returned in a term column, and inquiry will contain the step label. This can be used as an additional dimension for use in diagnosis.

**Value**

a function, `I()`, that accepts a `data.frame` as an argument and returns a `data.frame` containing the value of the inquiry,  $a^m$ .

**Examples**

```
# Set up a design for use in examples:
## Two-arm randomized experiment
design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ 0.2 * Z + X + U)
  ) +
  declare_assignment(Z = complete_ra(N = N, m = 250)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z))

# Some common inquiries
design +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0))

design +
  declare_inquiry(difference_in_var = var(Y_Z_1) - var(Y_Z_0))

design +
  declare_inquiry(mean_Y = mean(Y))

# Inquiries among a subset
design +
  declare_inquiry(ATT = mean(Y_Z_1 - Y_Z_0),
                 subset = (Z == 1))

design +
  declare_inquiry(CATE = mean(Y_Z_1 - Y_Z_0),
                 subset = X == 1)

# equivalently
design +
  declare_inquiry(CATE = mean(Y_Z_1[X == 1] - Y_Z_0[X == 1]))

# Add inquiries to a design along with estimators that
# reference them
diff_in_variances <-
  function(data) {
    data.frame(estimate = with(data, var(Y[Z == 1]) - var(Y[Z == 0])))
  }

design_1 <-
  design +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0),
```



```

        difference_in_var = var(Y_Z_1) - var(Y_Z_0)) +
declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
declare_estimator(Y ~ Z,
  inquiry = "ATE",
  label = "DIM") +
declare_estimator(handler =
  label_estimator(diff_in_variances),
  inquiry = "difference_in_var",
  label = "DIV")

run_design(design_1)

# Two inquiries using one estimator

design_2 <-
  design +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_inquiry(ATT = mean(Y_Z_1 - Y_Z_0), subset = (Z == 1)) +
  declare_estimator(Y ~ Z, inquiry = c("ATE", "ATT"))

run_design(design_2)

# Two inquiries using different coefficients from one estimator

design_3 <-
  design +
  declare_inquiry(intercept = mean(Y_Z_0),
    slope = mean(Y_Z_1 - Y_Z_0)) +
  declare_estimator(
    Y ~ Z,
    .method = lm_robust,
    term = TRUE,
    inquiry = c("intercept", "slope")
  )

run_design(design_3)

# declare_inquiries usage
design_4 <- design +
  declare_inquiries(
    ATE = mean(Y_Z_1[X == 1] - Y_Z_0[X == 1]),
    CATE_X0 = mean(Y_Z_1[X == 0] - Y_Z_0[X == 0]),
    CATE_X1 = mean(Y_Z_1[X == 1] - Y_Z_0[X == 1]),
    Difference_in_CATEs = CATE_X1 - CATE_X0,
    mean_Y = mean(Y))

```

**Description**

This function adds measured data columns that can be functions of unmeasured data columns.

**Usage**

```
declare_measurement(..., handler = measurement_handler, label = NULL)

measurement_handler(data, ...)
```

**Arguments**

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step
data	A data.frame.

**Details**

It is also possible to include measured variables in your `declare_model` call or to add variables using `declare_step`. However, putting latent variables in `declare_model` and variables-as-measured in `declare_measurement` helps communicate which parts of your research design are in M and which parts are in D.

**Value**

A function that returns a data.frame.

**Examples**

```
# declare_measurement in use
## Two-arm randomized experiment
design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ 0.2 * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N = N, n = 200)) +
  declare_assignment(Z = complete_ra(N = N, m = 100)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

# Reveal potential outcomes according to treatment assignment
design <-
  declare_model(N = 100,
    potential_outcomes(Y ~ rbinom(
      N, size = 1, prob = 0.1 * Z + 0.5
```

```

    ))) +
  declare_assignment(Z = complete_ra(N, m = 50)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z))

# Generate observed measurement from a latent value
design <-
  declare_model(N = 100, latent = runif(N)) +
  declare_measurement(observed = rbinom(N, 1, prob = latent))

# Index creation
library(psych)

design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    Y_1 = 0.2 * X + rnorm(N, sd = 0.25),
    Y_2 = 0.3 * X + 0.5 * rnorm(N, sd = 0.50),
    Y_3 = 0.1 * X + 0.4 * rnorm(N, sd = 0.75)) +
  declare_measurement(
    index = fa(
      r = cbind(Y_1, Y_2, Y_3),
      nfactors = 1,
      rotate = "varimax"
    )$scores
  )

draw_data(design)

```

---

declare\_model

*Declare the size and features of the population*


---

### Description

Declare the size and features of the population

### Usage

```
declare_model(..., handler = fabricate, label = NULL)
```

### Arguments

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step

**Value**

A function that returns a data.frame.

**Examples**

```
# declare_model is usually used when concatenating
# design elements with `+`

## Example: Two-arm randomized experiment
design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ 0.2 * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N = N, m = 250)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

# declare_model returns a function:
M <- declare_model(N = 100)
M()

# Declare a population from existing data
M <- declare_model(data = mtcars)

# Resample from existing data
M <- declare_model(N = 100, data = mtcars, handler = resample_data)

# Declare a model with covariates:
# observed covariates X1 and X2 and
# unobserved heterogeneity U that each affect
# outcome Y
M <- declare_model(
  N = 100,
  U = rnorm(N),
  X1 = rbinom(N, size = 1, prob = 0.5),
  X2 = X1 + rnorm(N),
  Y = 0.1 * X1 + 0.2 * X2 + 0.1 * X1 * X2 + U
)

# We can draw correlated variables using draw_multivariate
M <-
  declare_model(
    draw_multivariate(c(X1, X2) ~ MASS::mvrnorm(
      N = 1000,
      mu = c(0, 0),
      Sigma = matrix(c(1, 0.3, 0.3, 1), nrow = 2)
    )))
```

```

# Declare potential outcomes model dependent on assignment Z
## Manually
M <-
  declare_model(N = 100,
                Y_Z_0 = rbinom(N, size = 1, prob = 0.5),
                Y_Z_1 = rbinom(N, size = 1, prob = 0.6)
  )

## Using potential_outcomes
M <-
  declare_model(N = 100,
                potential_outcomes(Y ~ rbinom(N, size = 1, prob = 0.1 * Z + 0.5))
  )

## we can draw from a distribution of effect sizes
M <-
declare_model(
  N = 100,
  tau = runif(1, min = 0, max = 1),
  U = rnorm(N),
  potential_outcomes(Y ~ tau * Z + U)
)

## we can simulate treatment-by-covariate effect heterogeneity:
M <-
declare_model(
  N = 100,
  U = rnorm(N),
  X = rbinom(N, 1, prob = 0.5),
  potential_outcomes(Y ~ 0.3 * Z + 0.2*X + 0.1*Z*X + U)
)

## potential outcomes can respond to two treatments:
M <- declare_model(
  N = 6,
  U = rnorm(N),
  potential_outcomes(Y ~ Z1 + Z2 + U,
                    conditions = list(Z1 = c(0, 1), Z2 = c(0, 1))))

# Declare a two-level hierarchical population
# containing varying numbers of individuals within
# households and an age variable defined at the individual
# level
M <- declare_model(
  households = add_level(
    N = 100,
    N_members = sample(c(1, 2, 3, 4), N,
                      prob = c(0.2, 0.3, 0.25, 0.25),
                      replace = TRUE)
  ),
  individuals = add_level(

```

```

    N = N_members,
    age = sample(18:90, N, replace = TRUE)
  )
)

## Panel data have a more complex structure:
M <- declare_model(
  countries = add_level(
    N = 196,
    country_shock = rnorm(N)
  ),
  years = add_level(
    N = 100,
    time_trend = 1:N,
    year_shock = runif(N, 1, 10),
    nest = FALSE
  ),
  observation = cross_levels(
    by = join_using(countries, years),
    observation_shock = rnorm(N),
    Y = 0.01 * time_trend + country_shock + year_shock + observation_shock
  )
)

# Declare a population using a custom function
# the default handler is fabricatr::fabricate,
# but you can supply any function that returns a data.frame
my_model_function <- function(N) {
  data.frame(u = rnorm(N))
}

M <- declare_model(N = 10, handler = my_model_function)

```

---

declare\_sampling      *Declare sampling procedure*

---

### Description

Declare sampling procedure

### Usage

```
declare_sampling(..., handler = sampling_handler, label = NULL)
```

```
sampling_handler(data, ..., legacy = FALSE)
```

**Arguments**

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step
data	A data.frame.
legacy	Use the legacy randomizr functionality. This will be disabled in future; please use legacy = FALSE.

**Value**

A sampling declaration, which is a function that takes a data.frame as an argument and returns a data.frame subsetted to sampled observations and (optionally) augmented with inclusion probabilities and other quantities.

**Examples**

```
# declare_sampling in use
## Two-arm randomized experiment
design <-
  declare_model(
    N = 500,
    X = rep(c(0, 1), each = N / 2),
    U = rnorm(N, sd = 0.25),
    potential_outcomes(Y ~ 0.2 * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N = N, n = 200)) +
  declare_assignment(Z = complete_ra(N = N, m = 100)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

# Set up population to sample from
model <- declare_model(
  villages = add_level(
    N = 30,
    N_households = sample(c(50:100), N, replace = TRUE)
  ),
  households = add_level(
    N = N_households,
    N_members = sample(c(1, 2, 3, 4), N,
      prob = c(0.2, 0.3, 0.25, 0.25), replace = TRUE)
  ),
  individuals = add_level(
    N = N_members,
    age = sample(18:90, N, replace = TRUE),
    gender = rbinom(n = N, size = 1, prob = .5)
  )
)
```

```

)

# Sampling procedures
## Complete random sampling
design <- model +
  declare_sampling(S = complete_rs(N = N, n = 1000))

## Cluster random sampling
design <- model +
  declare_sampling(S = cluster_rs(clusters = villages,
                                n = 15))

## Strata and cluster random sampling
design <- model +
  declare_sampling(S = strata_and_cluster_rs(
    strata = villages,
    clusters = households,
    strata_n = rep(20, 30)))

## Stratified random sampling
design <- model +
  declare_sampling(S = strata_rs(strata = gender, n = 100))

```

---

declare_step	<i>Declare a custom step</i>
--------------	------------------------------

---

## Description

With `declare_step`, you can include any function that takes data as one of its arguments and returns data in a design declaration. The first argument is always a "handler", which is the name of the data-in, data-out function. For handy data manipulations use `declare_step(fabricate, ...)`.

## Usage

```

declare_step(
  ...,
  handler = function(data, ...f, ...) ...f(data, ...),
  label = NULL
)

```

## Arguments

...	arguments to be captured, and later passed to the handler
handler	a tidy-in, tidy-out function
label	a string describing the step



**Value**

A function that returns a data.frame.

**Examples**

```
population <- declare_model(N = 5, noise = rnorm(N))
manipulate <- declare_step(fabricate, noise_squared = noise^2, zero = 0)

design <- population + manipulate
draw_data(design)
```

---

declare_test	<i>Declare test</i>
--------------	---------------------

---

**Description**

Declares an test which generates a test statistic and associated inferential statistics.

Use of `declare_test` is identical to use of `declare_estimator`. Use `declare_test` for hypothesis testing with no specific inquiry in mind; use `declare_estimator` for hypothesis testing when you can link each estimate to an inquiry. For example, `declare_test` could be used for a K-S test of distributional equality and `declare_estimator` for a difference-in-means estimate of an average treatment effect.

See `declare_estimator` help for an explanation of how to use `method_handler`, which is used identically in both `declare_estimator` and `declare_test`. The main difference between `declare_estimator` and `declare_test` is that `declare_test` does not link with an explicit inquiry.

**Usage**

```
declare_test(..., handler = label_test(method_handler), label = "test")

label_test(fn)
```

**Arguments**

<code>...</code>	arguments to be captured, and later passed to the handler
<code>handler</code>	a tidy-in, tidy-out function
<code>label</code>	a string describing the step
<code>fn</code>	A function that takes a data.frame as an argument and returns a data.frame with test statistics as columns.

**Details**

`label_test` takes a data-in-data out function to `fn`, and returns a data-in-data-out function that first runs the provided test function `fn` and then appends a label for the test.

**Value**

A function that accepts a data.frame as an argument and returns a data.frame containing the value of the test statistic and other inferential statistics.

**See Also**

See [declare\\_estimator](#) for documentation of the method\_handler function.

**Examples**

```
# Balance test F test

balance_test_design <-
  declare_model(
    N = 100,
    cov1 = rnorm(N),
    cov2 = rnorm(N),
    cov3 = rnorm(N)
  ) +
  declare_assignment(Z = complete_ra(N, prob = 0.2)) +
  declare_test(Z ~ cov1 + cov2 + cov3, .method = lm_robust, .summary = glance)

## Not run:
diagnosis <- diagnose_design(
  design = balance_test_design,
  diagnosands = declare_diagnosands(
    false_positive_rate = mean(p.value <= 0.05))
)

## End(Not run)

# K-S test of distributional equality

ks_test <- function(data) {
  test <- with(data, ks.test(x = Y[Z == 1], y = Y[Z == 0]))
  data.frame(statistic = test$statistic, p.value = test$p.value)
}

distributional_equality_design <-
  declare_model(
    N = 100,
    Y_Z_1 = rnorm(N),
    Y_Z_0 = rnorm(N, sd = 1.5)
  ) +
  declare_assignment(Z = complete_ra(N, prob = 0.5)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_test(handler = label_test(ks_test), label = "ks-test")

## Not run:
diagnosis <- diagnose_design(
  design = distributional_equality_design,
```

```
    diagnosands = declare_diagnosands(power = mean(p.value <= 0.05))
  )

## End(Not run)

# Thanks to Jake Bowers for this example

library(coin)

our_ttest <- function(data) {
  res <- coin::oneway_test(
    outcome ~ factor(Xclus),
    data = data,
    distribution = "asymptotic"
  )
  data.frame(p.value = pvalue(res)[[1]])
}

ttest_design <-
  declare_model(
    N = 100,
    Xclus = rbinom(n = N, size = 1, prob = 0.2),
    outcome = 3 + rnorm(N) +
    declare_test(handler = label_test(our_ttest), label = "t-test")

## Not run:
diagnosis <- diagnose_design(
  design = ttest_design,
  diagnosands = declare_diagnosands(
    false_positive_rate = mean(p.value <= 0.05))
)

## End(Not run)
```

---

diagnosand\_handler      *Declare diagnosands*

---

## Description

Declare diagnosands

## Usage

```
diagnosand_handler(data, ..., subset = NULL, alpha = 0.05, label)
```

```
declare_diagnosands(..., handler = diagnosand_handler, label = NULL)
```

**Arguments**

data	A data.frame.
...	A set of new diagnosands.
subset	A subset of the simulations data frame within which to calculate diagnosands e.g. subset = p.value < .05.
alpha	Alpha significance level. Defaults to .05.
label	Label for the set of diagnosands.
handler	a tidy-in, tidy-out function

**Details**

If term is TRUE, the names of ... will be returned in a term column, and inquiry will contain the step label. This can be used as an additional dimension for use in diagnosis.

Diagnosands summarize the simulations generated by `diagnose_design` or `simulate_design`. Typically, the columns of the resulting simulations data.frame include the following variables: estimate, std.error, p.value, conf.low, conf.high, and inquiry. Many diagnosands will be a function of these variables.

**Value**

a function that returns a data.frame

**Examples**

```
design <-
  declare_model(
    N = 500,
    U = rnorm(N),
    Y_Z_0 = U,
    Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)
  ) +
  declare_assignment(Z = complete_ra(N)) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_estimator(Y ~ Z, inquiry = my_inquiry) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z))

## Not run:
# using built-in defaults:
diagnosis <- diagnose_design(design)
diagnosis

## End(Not run)

# You can choose your own diagnosands instead of the defaults e.g.,

my_diagnosands <-
  declare_diagnosands(median_bias = median(estimate - inquiry))
## Not run:
```

```

diagnosis <- diagnose_design(design, diagnosands = my_diagnosands)
diagnosis

## End(Not run)
## Not run:
design <- set_diagnosands(design, diagnosands = my_diagnosands)
diagnosis <- diagnose_design(design)
diagnosis

## End(Not run)

# If you do not specify diagnosands in diagnose_design,
# the function default_diagnosands() is used,
# which is reproduced below.

alpha <- 0.05

default_diagnosands <-
  declare_diagnosands(
    mean_estimand = mean(estimand),
    mean_estimate = mean(estimate),
    bias = mean(estimate - estimand),
    sd_estimate = sqrt(pop.var(estimate)),
    rmse = sqrt(mean((estimate - estimand) ^ 2)),
    power = mean(p.value <= alpha),
    coverage = mean(estimand <= conf.high & estimand >= conf.low)
  )

# A longer list of potentially useful diagnosands might include:

extended_diagnosands <-
  declare_diagnosands(
    mean_estimand = mean(estimand),
    mean_estimate = mean(estimate),
    bias = mean(estimate - estimand),
    sd_estimate = sd(estimate),
    rmse = sqrt(mean((estimate - estimand) ^ 2)),
    power = mean(p.value <= alpha),
    coverage = mean(estimand <= conf.high & estimand >= conf.low),
    mean_se = mean(std.error),
    type_s_rate = mean((sign(estimate) != sign(estimand))[p.value <= alpha]),
    exaggeration_ratio = mean((estimate/estimand)[p.value <= alpha]),
    var_estimate = pop.var(estimate),
    mean_var_hat = mean(std.error^2),
    prop_pos_sig = estimate > 0 & p.value <= alpha,
    mean_ci_length = mean(conf.high - conf.low)
  )

```

**Description**

Generates diagnosands from a design or simulations of a design.

**Usage**

```
diagnose_design(
  ...,
  diagnosands = NULL,
  sims = 500,
  bootstrap_sims = 100,
  make_groups = NULL,
  add_grouping_variables = NULL
)

diagnose_designs(
  ...,
  diagnosands = NULL,
  sims = 500,
  bootstrap_sims = 100,
  make_groups = NULL,
  add_grouping_variables = NULL
)

vars(...)
```

**Arguments**

...	A design or set of designs typically created using the + operator, or a data.frame of simulations, typically created by <a href="#">simulate_design</a> .
diagnosands	A set of diagnosands created by <a href="#">declare_diagnosands</a> . By default, these include bias, root mean-squared error, power, frequentist coverage, the mean and standard deviation of the estimate(s), the "type S" error rate (Gelman and Carlin 2014), and the mean of the inquiry(s).
sims	The number of simulations, defaulting to 500. sims may also be a vector indicating the number of simulations for each step in a design, as described for <a href="#">simulate_design</a>
bootstrap_sims	Number of bootstrap replicates for the diagnosands to obtain the standard errors of the diagnosands, defaulting to 100. Set to FALSE to turn off bootstrapping.
make_groups	Add group variables within which diagnosand values will be calculated. New variables can be created or variables already in the simulations data frame selected. Type name-value pairs within the function vars, i.e. vars(significant = p.value <= 0.05).
add_grouping_variables	Deprecated. Please use make_groups instead. Variables used to generate groups of simulations for diagnosis. Added to default list: c("design", "estimand_label", "estimator", "outcome", "term")

## Details

If the `diagnosand` function contains a `group_by` attribute, it will be used to split-apply-combine `diagnosands` rather than the intersecting column names.

If `sims` is named, or longer than one element, a fan-out strategy is created and used instead.

If the packages `future` and `future.apply` are installed, you can set `plan` to run multiple simulations in parallel.

## Value

a list with a data frame of simulations, a data frame of `diagnosands`, a vector of `diagnosand` names, and if calculated, a data frame of bootstrap replicates.

## Examples

```
design <-
  declare_model(
    N = 500,
    U = rnorm(N),
    Y_Z_0 = U,
    Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

## Not run:
# using built-in defaults:
diagnosis <- diagnose_design(design)
reshape_diagnosis(diagnosis, select = "Power")

## End(Not run)

## Not run:
# Adding a group for within group diagnosis:
diagnosis <- diagnose_design(design,
  make_groups = vars(significant = p.value <= 0.05),
)
diagnosis

diagnosis <- diagnose_design(design,
  make_groups =
    vars(effect_size =
      cut(estimand, quantile(estimand, (0:4)/4),
        include.lowest = TRUE)),
    )
diagnosis

## End(Not run)

# using a user-defined diagnosand
```

```

my_diagnosand <- declare_diagnosands(absolute_error = mean(abs(estimate - estimand)))

## Not run:
diagnosis <- diagnose_design(design, diagnosands = my_diagnosand)
diagnosis

get_diagnosands(diagnosis)

get_simulations(diagnosis)

## End(Not run)
# Using an existing data frame of simulations
## Not run:
simulations <- simulate_design(designs, sims = 2)
diagnosis <- diagnose_design(simulations_df = simulations_df)

## End(Not run)

# If you do not specify diagnosands, the function default_diagnosands() is used,
# which is reproduced below.

alpha <- 0.05

default_diagnosands <-
  declare_diagnosands(
    mean_estimand = mean(estimand),
    mean_estimate = mean(estimate),
    bias = mean(estimate - estimand),
    sd_estimate = sqrt(pop.var(estimate)),
    rmse = sqrt(mean((estimate - estimand) ^ 2)),
    power = mean(p.value <= alpha),
    coverage = mean(estimand <= conf.high & estimand >= conf.low)
  )

# A longer list of useful diagnosands might include:

extended_diagnosands <-
  declare_diagnosands(
    mean_estimand = mean(estimand),
    mean_estimate = mean(estimate),
    bias = mean(estimate - estimand),
    sd_estimate = sd(estimate),
    rmse = sqrt(mean((estimate - estimand) ^ 2)),
    power = mean(p.value <= alpha),
    coverage = mean(estimand <= conf.high & estimand >= conf.low),
    mean_se = mean(std.error),
    type_s_rate = mean((sign(estimate) != sign(estimand))[p.value <= alpha]),
    exaggeration_ratio = mean((estimate/estimand)[p.value <= alpha]),
    var_estimate = pop.var(estimate),
    mean_var_hat = mean(std.error^2),
    prop_pos_sig = estimate > 0 & p.value <= alpha,

```



```

    mean_ci_length = mean(conf.high - conf.low)
  )

```

---

diagnosis\_helpers      *Explore your design diagnosis*

---

## Description

Explore your design diagnosis

## Usage

```
get_diagnosands(diagnosis)
```

```
get_simulations(diagnosis)
```

## Arguments

`diagnosis`      A design diagnosis created by [diagnose\\_design](#).

## Examples

```

design <-
  declare_model(
    N = 500,
    U = rnorm(N),
    Y_Z_0 = U,
    Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)
  ) +
  declare_assignment(Z = complete_ra(N)) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

## Not run:
# using built-in defaults:
diagnosis <- diagnose_design(design)
diagnosis

## End(Not run)

# using a user-defined diagnosand
my_diagnosand <- declare_diagnosands(
  absolute_error = mean(abs(estimate - estimand)))

## Not run:
diagnosis <- diagnose_design(design, diagnosands = my_diagnosand)
diagnosis

```

```

get_diagnosands(diagnosis)

get_simulations(diagnosis)

reshape_diagnosis(diagnosis)

## End(Not run)

```

---

draw_functions	<i>Draw data, estimates, and inquiries from a design</i>
----------------	--

---

### Description

Draw data, estimates, and inquiries from a design

### Usage

```

draw_data(design, data = NULL, start = 1, end = length(design))

draw_estimand(...)

draw_estimands(...)

draw_estimates(...)

```

### Arguments

design	A design object, typically created using the + operator
data	A data.frame object with sufficient information to get the data, estimates, inquiries, an assignment vector, or a sample.
start	(Defaults to 1) a scalar indicating which step in the design to begin with. By default all data steps are drawn, from step 1 to the last step of the design.
end	(Defaults to length(design)) a scalar indicating which step in the design to finish drawing data by.
...	A design or set of designs typically created using the + operator

### Examples

```

design <-
  declare_model(
    N = 100,
    U = rnorm(N),
    potential_outcomes(Y ~ Z + U)
  ) +

```

```

declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
declare_sampling(S = complete_rs(N, n = 75)) +
declare_assignment(Z = complete_ra(N, m = 50)) +
declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
declare_estimator(Y ~ Z, inquiry = "ATE")

dat <- draw_data(design)

dat_no_sampling <- draw_data(design, end = 3)

draw_estimands(design)

draw_estimates(design)

```

---

expand_design	<i>Declare a design via a designer</i>
---------------	--

---

### Description

expand\_design easily generates a set of design from a designer function.

### Usage

```
expand_design(designer, ..., expand = TRUE, prefix = "design")
```

### Arguments

designer	a function which yields a design
...	Options sent to the designer
expand	boolean - if true, form the crossproduct of the ..., otherwise recycle them
prefix	prefix for the names of the designs, i.e. if you create two designs they would be named prefix_1, prefix_2

### Value

if set of designs is size one, the design, otherwise a 'by'-list of designs. Designs are given a parameters attribute with the values of parameters assigned by expand\_design.

### Examples

```

## Not run:

# in conjunction with DesignLibrary

library(DesignLibrary)

```

```

designs <- expand_design(multi_arm_designer, outcome_means = list(c(3,2,4), c(1,4,1)))

# with a custom designer function

designer <- function(N) {
  pop <-
    declare_model(
      N = N,
      U = rnorm(N),
      potential_outcomes(Y ~ 0.20 * Z + U)
    )
  assgn <- declare_assignment(Z = complete_ra(N, m = N/2))
  inquiry <- declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0))
  estimator <- declare_estimator(Y ~ Z, inquiry = inquiry)
  pop + pos + assgn + inquiry + estimator
}

# returns list of eight designs
designs <- expand_design(designer, N = seq(30, 100, 10))

# diagnose a list of designs created by expand_design or redesign
diagnosis <- diagnose_design(designs, sims = 50)

# returns a single design
large_design <- expand_design(designer, N = 200)

diagnose_large_design <- diagnose_design(large_design, sims = 50)

## End(Not run)

```

---

get\_functions

*Get estimates, inquiries, assignment vectors, or samples from a design given data*

---

## Description

Get estimates, inquiries, assignment vectors, or samples from a design given data

## Usage

```
get_estimates(design, data = NULL, start = 1, end = length(design))
```

## Arguments

design	A design object, typically created using the + operator
data	A data.frame object with sufficient information to get the data, estimates, inquiries, an assignment vector, or a sample.

`start` (Defaults to 1) a scalar indicating which step in the design to begin with. By default all data steps are drawn, from step 1 to the last step of the design.

`end` (Defaults to `length(design)`) a scalar indicating which step in the design to finish with.

## Examples

```
design <-
  declare_model(
    N = 100,
    U = rnorm(N),
    potential_outcomes(Y ~ Z + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_sampling(S = complete_rs(N, n = 75)) +
  declare_assignment(Z = complete_ra(N, m = 50)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

dat <- draw_data(design)

draw_data(design, data = dat, start = 2)

get_estimates(design, data = dat)
```

---

<code>modify_design</code>	<i>Modify a design after the fact</i>
----------------------------	---------------------------------------

---

## Description

Insert, delete and replace steps in an (already declared) design object.

## Usage

```
insert_step(design, new_step, before, after)
```

```
delete_step(design, step)
```

```
replace_step(design, step, new_step)
```

## Arguments

<code>design</code>	A design object, usually created using the <code>+</code> operator, <a href="#">expand_design</a> , or the design library.
<code>new_step</code>	The new step; Either a function or a partial call.
<code>before</code>	The step before which to add steps.
<code>after</code>	The step after which to add steps.
<code>step</code>	The quoted label of the step to be deleted or replaced.

## Details

See [modify\\_design](#) for details.

## Value

A new design object.

## Examples

```
my_model <-
  declare_model(
    N = 100,
    U = rnorm(N),
    Y_Z_0 = U,
    Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)
  )

my_assignment <- declare_assignment(Z = complete_ra(N, m = 50))
my_assignment_2 <- declare_assignment(Z = complete_ra(N, m = 25))

design <- my_model + my_assignment

design

## Not run:
insert_step(design, declare_step(dplyr::mutate, income = noise^2),
            after = my_assignment)
insert_step(design, declare_step(dplyr::mutate, income = noise^2),
            before = my_assignment)

# If you are using a design created by a designer, for example from
# the DesignLibrary package, you will not have access to the step
# objects. Instead, you can always use the label of the step.

# get the labels for the steps
names(design)

insert_step(design,
            declare_sampling(S = complete_rs(N, n = 50),
                             legacy = FALSE,
                             after = "my_pop")

## End(Not run)

delete_step(design, my_assignment)
replace_step(design, my_assignment, declare_step(dplyr::mutate, words = "income"))
```

---

pop.var	<i>Population variance function</i>
---------	-------------------------------------

---

**Description**

Population variance function

**Usage**

```
pop.var(x, na.rm = FALSE)
```

**Arguments**

x                    a numeric vector, matrix or data frame.  
na.rm                logical. Should missing values be removed?

**Value**

numeric scalar of the population variance

**Examples**

```
x <- 1:4  
var(x) # divides by (n-1)  
pop.var(x) # divides by n
```

---

post_design	<i>Explore your design</i>
-------------	----------------------------

---

**Description**

Explore your design  
Print code to recreate a design

**Usage**

```
print_code(design)  
  
## S3 method for class 'design'  
print(x, verbose = FALSE, ...)  
  
## S3 method for class 'design'  
summary(object, verbose = TRUE, ...)
```

**Arguments**

design	A design object, typically created using the + operator
x	a design object, typically created using the + operator
verbose	an indicator for printing a long summary of the design, defaults to TRUE
...	optional arguments to be sent to summary function
object	a design object created using the + operator

**Examples**

```

design <-
  declare_model(
    N = 500,
    U = rnorm(N),
    potential_outcomes(Y ~ U + Z * rnorm(N, 2, 2))
  ) +
  declare_sampling(S = complete_rs(N, n = 250)) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N, m = 25)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "my_inquiry")

design

df <- draw_data(design)

estimates <- draw_estimates(design)
inquiries <- draw_estimands(design)

print_code(design)

my_population <- declare_model(N = 100)

my_assignment <- declare_assignment(Z = complete_ra(N, m = 50))

my_design <- my_population + my_assignment

print_code(my_design)

my_model <-
  declare_model(
    N = 500,
    noise = rnorm(N),
    Y_Z_0 = noise,
    Y_Z_1 = noise + rnorm(N, mean = 2, sd = 2)
  )

my_sampling <- declare_sampling(S = complete_rs(N, n = 250))

```



```

my_assignment <- declare_assignment(Z = complete_ra(N, m = 25))

my_inquiry <- declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0))

my_estimator <- declare_estimator(Y ~ Z, inquiry = my_inquiry)

my_reveal <- declare_measurement(Y = reveal_outcomes(Y ~ Z))

design <- my_model +
  my_sampling +
  my_inquiry +
  my_assignment +
  my_reveal +
  my_estimator

summary(design)

```

---

redesign

*Redesign*


---

### Description

redesign quickly generates a design from an existing one by resetting symbols used in design handler parameters in a step's environment (Advanced).

### Usage

```
redesign(design, ..., expand = TRUE)
```

### Arguments

design	An object of class design.
...	Arguments to redesign e.g., $n = 100$ . If redesigning multiple arguments, they must be specified as a named list.
expand	If TRUE, redesign using the crossproduct of ..., otherwise recycle them.

### Details

Warning: redesign will edit any symbol in your design, but if the symbol you attempt to change does not exist in a step's environment no changes will be made and no error or warning will be issued.

Please note that redesign functionality is experimental and may be changed in future versions.

### Value

A design, or, in the case of multiple values being passed onto ..., a 'by'-list of designs.

**Examples**

```

n <- 500
population <- declare_model(N = 1000)
sampling <- declare_sampling(S = complete_rs(N, n = n),
                             legacy = FALSE)
design <- population + sampling

# returns a single, modified design
modified_design <- redesign(design, n = 200)

# returns a list of six modified designs
design_vary_N <- redesign(design, n = seq(400, 900, 100))

# When redesigning with arguments that are vectors,
# use list() in redesign, with each list item
# representing a design you wish to create

prob_each <- c(.1, .5, .4)

assignment <- declare_assignment(
  Z = complete_ra(prob_each = prob_each),
  legacy = FALSE)

design <- population + assignment

# returns two designs

designs_vary_prob_each <- redesign(
  design,
  prob_each = list(c(.2, .5, .3), c(0, .5, .5)))

# To illustrate what does and does not get edited by redesign,
# consider the following three designs. In the first two, argument
# X is called from the step's environment; in the third it is not.
# Using redesign will alter the role of X in the first two designs
# but not the third one.

X <- 3
f <- function(b, X) b*X
g <- function(b) b*X

design1 <- declare_model(N = 1, A = X)      + NULL
design2 <- declare_model(N = 1, A = f(2, X)) + NULL
design3 <- declare_model(N = 1, A = g(2))  + NULL

draw_data(design1)
draw_data(design2)
draw_data(design3)

draw_data(redesign(design1, X=0))

```

```
draw_data(redesign(design2, X=0))
draw_data(redesign(design3, X=0))
```

---

```
reshape_diagnosis      Clean up a diagnosis object for printing
```

---

## Description

Take a diagnosis object and returns a pretty output table. If diagnosands are bootstrapped, se's are put in parentheses on a second line and rounded to digits.

## Usage

```
reshape_diagnosis(diagnosis, digits = 2, select = NULL, exclude = NULL)
```

## Arguments

diagnosis	A diagnosis object generated by diagnose_design.
digits	Number of digits.
select	List of columns to include in output. Defaults to all.
exclude	Set of columns to exclude from output. Defaults to none.

## Value

A formatted text table with bootstrapped standard errors in parentheses.

## Examples

```
effect_size <- 0.1
design <-
  declare_model(
    N = 100,
    U = rnorm(N),
    X = rnorm(N),
    potential_outcomes(Y ~ effect_size * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE", label = "unadjusted") +
  declare_estimator(Y ~ Z + X, inquiry = "ATE", label = "adjusted")

diagnosis <- diagnose_design(design, sims = 100)

reshape_diagnosis(diagnosis)

reshape_diagnosis(diagnosis, select = c("Bias", "Power"))
```

---

run_design	<i>Run a design one time</i>
------------	------------------------------

---

**Description**

Run a design one time

**Usage**

```
run_design(design)
```

**Arguments**

design            a DeclareDesign object

**Examples**

```
design <-
  declare_model(
    N = 100, X = rnorm(N),
    potential_outcomes(Y ~ (.25 + X) * Z + rnorm(N))
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N, m = 50)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE")

run_design(design)
```

---

set_citation	<i>Set the citation of a design</i>
--------------	-------------------------------------

---

**Description**

Set the citation of a design

**Usage**

```
set_citation(
  design,
  title = NULL,
  author = NULL,
  year = NULL,
  description = "Unpublished research design declaration",
  citation = NULL
)
```

**Arguments**

design	A design typically created using the + operator
title	The title of the design, as a character string.
author	The author(s) of the design, as a character string.
year	The year of the design, as a character string.
description	A description of the design in words, as a character string.
citation	(optional) The preferred citation for the design, as a character string, in which case title, author, year, and description may be left unspecified.

**Value**

a design object with a citation attribute

**Examples**

```
design <-  
declare_model(data = sleep) +  
  declare_sampling(S = complete_rs(N, n = 10))  
  
design <-  
  set_citation(design,  
              author = "Lovelace, Ada",  
              title = "Notes",  
              year = 1953,  
              description = "This is a text description of a design")  
  
cite_design(design)
```

---

set_diagnosands	<i>Set the diagnosands for a design</i>
-----------------	---

---

**Description**

A researcher often has a set of diagnosands in mind to appropriately assess the quality of a design. `set_diagnosands` sets the default diagnosands for a design, so that later readers can assess the design on the same terms as the original author. Readers can also use `diagnose_design` to diagnose the design using any other set of diagnosands.

**Usage**

```
set_diagnosands(x, diagnosands = default_diagnosands)
```

**Arguments**

- `x` A design typically created using the `+` operator, or a simulations data.frame created by `simulate_design`.
- `diagnosands` A set of diagnosands created by [declare\\_diagnosands](#)

**Value**

a design object with a `diagnosand` attribute

**Examples**

```
design <-
declare_model(data = sleep) +
  declare_inquiry(mean_outcome = mean(extra)) +
  declare_sampling(S = complete_rs(N, n = 10)) +
  declare_estimator(extra ~ 1, inquiry = "mean_outcome",
    term = '(Intercept)', .method = lm_robust)

diagnosands <- declare_diagnosands(
  median_bias = median(estimate - inquiry))

design <- set_diagnosands(design, diagnosands)

## Not run:
diagnose_design(design)

simulations_df <- simulate_design(design)

simulations_df <- set_diagnosands(simulations_df, design)

diagnose_design(simulations_df)

## End(Not run)
```

---

simulate_design	<i>Simulate a design</i>
-----------------	--------------------------

---

**Description**

Runs many simulations of a design and returns a simulations data.frame.

**Usage**

```
simulate_design(..., sims = 500)

simulate_designs(..., sims = 500)
```

## Arguments

...	A design created using the + operator, or a set of designs. You can also provide a single list of designs, for example one created by <a href="#">expand_design</a> .
sims	The number of simulations, defaulting to 500. If sims is a vector of the form c(10, 1, 2, 1) then different steps of a design will be simulated different numbers of times.

## Details

Different steps of a design may each be simulated different a number of times, as specified by sims. In this case simulations are grouped into "fans". The nested structure of simulations is recorded in the dataset using a set of variables named "step\_x\_draw." For example if sims = c(2,1,1,3) is passed to simulate\_design, then there will be two distinct draws of step 1, indicated in variable "step\_1\_draw" (with values 1 and 2) and there will be three draws for step 4 within each of the step 1 draws, recorded in "step\_4\_draw" (with values 1 to 6).

## Examples

```
my_model <-
  declare_model(
    N = 500,
    U = rnorm(N),
    Y_Z_0 = U,
    Y_Z_1 = U + rnorm(N, mean = 2, sd = 2)
  )

my_assignment <- declare_assignment(Z = complete_ra(N))

my_inquiry <- declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0))

my_estimator <- declare_estimator(Y ~ Z, inquiry = my_inquiry)

my_reveal <- declare_measurement(Y = reveal_outcomes(Y ~ Z))

design <- my_model +
  my_inquiry +
  my_assignment +
  my_reveal +
  my_estimator

## Not run:
simulations <- simulate_design(designs, sims = 2)
diagnosis <- diagnose_design(simulations_df = simulations)

## End(Not run)

## Not run:
# A fixed population with simulations over assignment only
head(simulate_design(design, sims = c(1, 1, 1, 100, 1)))

## End(Not run)
```

---

tidy.diagnosis	<i>Tidy diagnosis</i>
----------------	-----------------------

---

**Description**

Tidy diagnosis

**Usage**

```
## S3 method for class 'diagnosis'
tidy(x, conf.int = TRUE, conf.level = 0.95, ...)
```

**Arguments**

x	A diagnosis object generated by <code>diagnose_design</code> .
conf.int	Logical indicating whether or not to include a confidence interval in the tidied output. Defaults to 'TRUE'.
conf.level	The confidence level to use for the confidence interval if 'conf.int = TRUE'. Must be strictly greater than 0 and less than 1. Defaults to 0.95, which corresponds to a 95 percent confidence interval.
...	extra arguments (not used)

**Value**

A data.frame with columns for diagnosand names, estimated diagnosand values, bootstrapped standard errors and confidence intervals

**Examples**

```
effect_size <- 0.1
design <-
  declare_model(
    N = 100,
    U = rnorm(N),
    X = rnorm(N),
    potential_outcomes(Y ~ effect_size * Z + X + U)
  ) +
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +
  declare_assignment(Z = complete_ra(N)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +
  declare_estimator(Y ~ Z, inquiry = "ATE", label = "unadjusted") +
  declare_estimator(Y ~ Z + X, inquiry = "ATE", label = "adjusted")

diagnosis <- diagnose_design(design, sims = 100)

tidy(diagnosis)
```



---

`tidy_try`*Tidy Model Results and Filter to Relevant Coefficients*

---

**Description**

Tidy function that returns a tidy data.frame of model results and allows filtering to relevant coefficients. The function will attempt to tidy model objects even when they do not have a tidy method available. For best results, first load the broom package via `library(broom)`.

**Usage**

```
tidy_try(fit, term = FALSE)
```

**Arguments**

<code>fit</code>	A model fit, as returned by a modeling function like <code>lm</code> , <code>glm</code> , or <code>estimatr::lm_robust</code> .
<code>term</code>	A character vector of the terms that represent quantities of interest, i.e., "Z". If <code>FALSE</code> , return the first non-intercept term; if <code>TRUE</code> return all terms.

**Value**

A data.frame with coefficient estimates and associated statistics.

**Examples**

```
fit <- lm(mpg ~ hp + disp + cyl, data = mtcars)
tidy_try(fit)
```

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